INTEGRATED RENEWABLE RESOURCE MANAGEMENT FOR U.S. INSULAR AREAS

Volume II: Commissioned Papers

Part D: Agroforestry and Forestry

1. The Marshall Islands Coconut Industry: Prospects for Expansion and Development
   (Skip Polson)
2. Forestry and Agroforestry Technologies: Developmental Potentials in the U.S.-Affiliated Pacific Islands
   (Craig C. Halbower)
3. Congressional Action to Improve the Sustainability of U.S. Tropical Forest Resources in the Pacific*
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5. Forestry: Puerto Rico and the U.S. Virgin Islands*
   (Ralph Schmidt)
6. Forestry in Puerto Rico: A Case Study in Successful Organizational Change
   (Hilda Diaz-Soltero and Ralph Schmidt)

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* Paper commissioned for OTA assessment of Technologies to Sustain Tropical Forest Resources, Washington, DC: U.S. Government Printing Office, 1984.

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Background Paper No. 1

THE MARSHALL ISLANDS COCONUT INDUSTRY: PROSPECTS FOR EXPANSION AND DEVELOPMENT

(Author's Draft)

by

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Condensed by Susan J. Wintsch

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ABSTRACT

The coconut palm (Cocos nucifera) has always contributed significantly to the subsistence lifestyle of Marshall Islanders. In the mid-1800s, German traders introduced copra making to the Marshallese, and it has been their primary source of export earning ever since.

Between 1914 and 1941, the Japanese greatly expanded copra production in the Marshalls to just over 6,000 short tons per year. Production ceased during World War II, and did not fully resume until several years after the war. Production has averaged 5,860 short tons per year since 1961. All Marshallese copra is processed into coconut oil and copra meal by the Tobolar Copra Processing Plant, Inc. in Majuro. The Marshalls produce under one percent of total world exports of coconut oil.

Few alternative uses of coconut products are likely to be economic in the Marshalls; the coconut industry there can probably provide only slightly higher sustained incomes for copra producers than they now earn. Several Marshallese institutions are trying to increase public awareness of the coconut industry's importance to the local economy and to promote production. Production levels are influenced by weather conditions, land fragmentation within each atoll, labor availability, transportation services, and producer prices. Although little research has been done on these and other aspects of coconut production in the Marshalls, research in other countries could be relevant. The U.S. government can help by supporting research and extension efforts, and by providing advice and assistance with export marketing.

INTRODUCTION

HISTORICAL BACKGROUND

The coconut palm (Cocos nucifera Linn.) has always contributed significantly to the lifestyle of the Marshallese Islanders. Legend portrays the first coconut as a baby born to a woman on Ailinglaplap. The coconut-child asked to be planted outside her house, and it grew to provide her with food, drink, fuel, shelter, timber, and useful fibers.

The "miracle tree" of legend is almost miraculously useful, and generations of islanders have carried coconuts as they explored and settled the Pacific; they were almost certainly responsible for spreading coconuts throughout the region, since seednuts lose their viability after floating in salt water for a few days (Thampan, 1981). In the mid-1800s, when outsiders came to explore and prospect for exploitable resources, they found whales and another source of soil in the coconut palms that grew on the islands.

DEVELOPMENT OF COCONUT CASH CROPS

The German Period

German copra traders established their first trading station in all of Micronesia in the Marshalls. When Adolf Capelle organized copra production on Ebon Atoll in 1846 and encouraged expansion of the area planted to coconuts, the number of palms on the islands probably did not greatly exceed local consumption needs. Capelle and a Portuguese named DeBrum together purchased parts of Likiep Atoll for use as a copra plantation. In the mid-1860s, a number of German companies were active in Micronesia (Capelle and Company in the Marshalls and Ponape; Godeffroy and Sons on Yap, Kosrae, Ponape and Ebon; Hernsheim and Company on Palau, Woleai, Yap and Jaluit; and the Deutches Handels und Plantagenesellschaft on Losap, Lukunor, Nukuoro, Ponape, Palau, Ulithi and Yap), and by 1870 copra was the primary export product of Micronesia. In 1887, the leading German firms formed the Jaluit Company which dominated the copra trade until the end of the German period (Wilson, 1953).

Competition in the Micronesian copra trade came from several Japanese companies during the 1890s, but by 1901 these firms had been barred from doing business there because some of them had sold firearms to the Micronesians. German monopoly in the islands continued until 1905 when international pressure resulted in readmittance of Japanese companies. Economic competition increased until the beginning of World War I in 1914, when Japanese forces occupied the islands, and the German traders left.

Japanese Time

Most of Micronesia, including the Marshall Islands, was mandated to Japan by the League of Nations after the war. This mandate, which continued until the demise of the League at the end of World War II, gave the Japanese complete administrative and economic control of the islands, and they established a much more extensive presence than the Germans. A Japanese style government structure extended down to the village level on each atoll, and a wide variety of economic enterprises were introduced (Tables 1 and 2). (Since the Japanese referred to the Marshall Islands as Jaluit District, the statistics for the Marshalls are under the Jaluit heading.)

Sugar production in the Northern Marianas; phosphate mining on Angaur; and dried bonito processing in Truk, Palau, Saipan, Tinian, Ponape and Yap all yielded more export revenue than coconut products had in 1940. Coconut products in 1940 accounted for less than eight percent of Micronesia's total export value (Table 3).

The low coral atolls of the Marshalls have no significant phosphate deposits and no land suitable for sugar cane or rice. Coconut palms thus remained the atolls' major exploitable resource. The Japanese provided subsidies to increase coconut acreage and introduced improved planting and cultivation techniques. Estiamtes of the acreage devoted to coconut palms in the Marshalls increased 16.6 percent from 25,644 in 1923 to 29,901 in 1938 (Nathan, 1966; Stewart, 1971), and coconut products accounted for 91 percent of the Marshall Islands' total export value in 1940 (Table 4). In addition to copra, "rope, cordage and twine" almost certainly made from coir (fibers of coconut husks) and other coir products were exported.

In the course of a century, then, the Marshallese had gone from subsistence production to an annual production of some 36 million nuts in excess of their consumption needs (approximately the amount required to make 6,000 tons of copra about the 1938 production level). Under the German and Japanese regimes, the Marshallese had also acquired a taste for imported foods, become familiar with many manufactured goods, and demonstrated that they could act in their own economic self-interest. Their response to taxation illustrates this well: Marshallese tradition required that the copra yield be divided equally between the iroij (traditional nobles) and the commoners. This was done by giving the first half year's production to the iroij (of a given piece of land) and the second half year's production to the commoners. Then the Germans taxed the iroij's share of the copra. The Japanese klept the copra tax but defined the iroij's share as half the annual production. This was done because the commoners were withholding and delaying some of the first half year's production (Wilson, 1953).

Japanese capital, technology, management and initiative were essential to Japanese enterprises in Micronesia. The only enterprise to resume after Second World War disruption was copra production. Coconut palms had not been extensively damaged, except on a few islands where fighting had been particularly intense (e.g., Kwajalein, Saipan and Enewetok). Since coconut production requires very little capital and equipment, individuals and families could resume their roles as independent producers, operating much as they had prior to the war. Thus, in the post-war period throughout Micronesia, and especially in the Marshall Islands, copra continued to be a primary source of cash income. (From 1957 through 1962, copra accounted for 83 percent of all exports from the Trust Territory (Solomon, 1963).)

United States Administration

The return to pre-war production levels took several years to accomplish. Neglected coconut groves required clearing and thinning. New marketing channels to U.S. buyers had to be established. Tools and equipment were in short supply on the outer islands after the war years. The U.S. Naval administration of the Trust Territory had to determine its approach to private business in the area, and new inter-island shipping arrangements had to be made. The Marshallese raised copra production slowly, to about 120 short tons by 1945. Production totals for 1946-1960 are not available, but over 6,000 tons were produced in 1961 and production has remained at about that level since. Average annual production from 1961 to 1984 was 5,860 short tons. The best pre-war production year (1938) has been surpassed only five times.

SIGNIFICANCE OF THE COCONUT INDUSTRY IN THE MARSHALL ISLANDS

Wage employment in the Marshalls is largely restricted to Majuro and Kwajalein Atolls. Most outer island residents other than government-employed teachers and health aides earn most of their cash income from copra. Given the remoteness of the outer atolls and their relatively limited natural resources, this is likely to be the case for the foreseeable future.

Outer islanders use their copra income to purchase imported foods, clothing, building materials, fishing gear, kerosene, lanterns, tools, tobacco and trips to Majuro. Copra income also supports churches, other community activities, and pays taxes. In other words, Marshallese people participate actively in a modern monetary economy, largely because of their coconut industry.

Coconut palms also have important tarditional subsistence uses, and the

Marshallese (like other Pacific islanders) have developed many uses for almost every part of the palm. They drink the juice from immature nuts and sap, eat the meat in various preparations and feed it to their pigs and chickens. Fronds can be woven into thatch, baskets, food platters, hats, sitting mats, window shutters, and the walls of simple houses. Husks and shells provide cooking fuel in an environment with very limited supplies of other fuelwood. Husk fibers can be spun into twine and rope; trunks can be used for lumber and posts. Thus, the coconut palm is an integral part of daily life in the Marshalls. It is hard to imagine the islands without them. They are the dominant visual feature of the atolls and a key renewable resource.

RELEVANCE OF THIS ANALYSIS TO OTHER ISLAND AREAS

Most aspects of this analysis of the Marshallese coconut industry are relevant to the other island groups. Copra making techniques are almost identical on even the high islands, although coconut products play a smaller role in both the cash and subsistence economies of the high islands.

DESCRIPTION OF THE EXISTING COCONUT INDUSTRY

GENERAL CHARACTERISTICS

There is very little regular cultivation or maintenance of coconut palms on the Marshall Islands. Brush between the palms is cleared occasionally and burned along with accumulations of old fronds and husks. Fertilizers are not used, and mature nuts are simply collected once they have fallen.

In general, new trees are planted only if government programs subsidize mechanized equipment and/or seednuts. Agricultural extension workers typically call for seedlings to be planted 28 feet apart on a square pattern in composted three-foot square cubical holes. This yields a density of 55 trees per acre (137 trees per hectare).

Replanting without government assistance is rare for several reasons: (1) the substantial investment of time and effort required; (2) the seven-year wait before the trees bear fruit and provide a return on that investment; (3) the fact that unattended nuts will sprout by themselves with no labor input; and (4) the knowledge that government is likely to provide assistance and superior seednuts. Few Marshallese know firsthand that composting and extra care at planting time will result in a healthier, more productive tree.

ACREAGE ESTIMATES

Estimates of the post-war acreage devoted to coconut production range from 25,000 to 26,000 acres (Stewart, 1971; Santhiapillai, 1980), or about 57 percent of the total land area of the Marshalls (44,698 acres) (Bryan, 1971).

These are estimates, not precise measurements, however, and coconut palms are dispersed throughout the Marshall Islands with highly variable density. Few pure stands exist. Typically, other plant species are interspersed among the palms, including breadfruit, pandanus, arrowroot, limes, bananas, native trees used for poles and posts, and numerous medicinal plants and grasses.

Reliable statistical information is also lacking on other basic aspects of copra production in the Marshalls. Average yield per tree, yields per acre at different planting densities, domestic consumption of fresh nuts, variations in soil quality and rainfall from atoll to atoll, and other production-related factors have simply not been analyzed scientifically.

LOCAL COCONUT VARIETIES

There are many local varieties of coconut palm in the Marshall Islands. The Marshallese people distinguish them primarily by the color, size, shape and number of nuts per bunch, and by the flavor of their water and meat. Agriculturalists have identified at least seven tall and four dwarf varieties also named by the Marshallese (Sproat, 1965). In the early 1960s, a new variety of the common tall coconut palm was distributed from Yap to other parts of Micronesia, including the Marshalls. This variety (called Thifow) has large, ovoid fruits with thick kernels and relatively thin husks. It produces well in atoll conditions and a short ton of copra can reportedly be produced from only 3,300 nuts (about 6,000 nuts of traditional Marshallese varieties are required for same). The initial shipments of these seednuts to the Marshalls were planted on Majuro, Jaluit and Namdrik atolls. Nuts produced from those trees are now used in the government's replanting efforts on other atolls.

FACTORS INFLUENCING PRODUCTION

Many factors affect the number and size of nuts produced each year in the Marshalls. Long-term weather conditions are particularly influential since almost seven years pass from the initial stage of a leaf's formation in the palm heart until nuts mature (Thampan, 1981). Occasional drought and typhoon damage can reduce yields for several years at a time, but the islands are relatively free of diseases and insect pests; the rhinoceros beetle (*Oryctes rhinocerus*) which causes extensive damage to palms in other island groups is not found in the Marshalls. On some atolls, rats significantly damage young coconuts; control efforts have included trapping, poisoning and bringing additional cats to the affected islands.

Rainfall, land fragmentation, and labor availability differ from atoll to atoll (Tables 6 and 7). Those closest to the equator receive the most rainfall, and in general have the highest yields of copra, except where productive land is scattered over an extensive reef. The most fragmented atolls (i.e., Ailuk) generally have the lowest productivity per acre. (Moreover, in such situations transportation becomes more difficult and time consuming.) Many of the tiniest islands also do not have a substantial fresh water lens or shelter to protect coconut palms from wind and salt spray. Between 1978 and 1983, the four inhabited single islands in the Marshalls produced 105 percent more copra per acre than the 20 atolls (Appendix A). The highest yields per acre were recorded on the single island Mejit, and on Namdrik and Ebon atolls which rank first and third in the Marshalls in terms of land area per island.

Government wage rates strongly influence the Marshallese coconut industry. High minimum wages of government workers and of Kwajalein Missile Range (KMR) employees seriously reduce the labor available for productive industry and private enterprise.

COPRA MAKING TECHNIQUES

Copra production in the Marshall Islands is very labor-intensive. The work is physically strenuous, hot and monotonous, but relatively simple. Axes, copra cutting knives (double-edged with a straight blade 4-6 inches long), husking stakes, a drying rack, gunny sacks, and possibly a cart are all that is required. Most copra making is done in family groups or by related individuals on land they share.

The traditional Marshallese land tenure system divides each island into relatively small plots. Use rights are inherited and normally shared by a number of individuals who also share whatever wealth they accumulate. Current law does not allow foreigners to own land in the Marshalls, essentially precluding plantation style production. While traditional systems provide relatively equitable access to resources, these wealth-sharing traditions have been cited as inhibitors of individual initiative (Sproat, 1968). On the positive side, "shared ownership" practices provide equity and social welfare benefits, and it is not at all clear that the Marshallese people would be better off by adopting "western" attitudes toward land and wealth.

Most copra-drying racks are located near producers' houses. For ease of transportation, most nuts are either husked or split and stripped of meat in the field before being taken to the drier. The exact process depends on whether cup copra or cut copra is made. To make cup copra the nuts are husked, split open and then partially dried in the sun or on a hot air drier for a day or two. This causes the kernel to shrink and separate from the shell. For cut (or strip) copra, whole unhusked nuts are split open lengthwise with an axe; kernels are removed by slicing the meat into strips with a copra knife. The fresh meat is transported to the drier.

Husking is done with either a wooden stick or a yard-long metal pipe tapered to a sharp point on one end and stuck firmly in the ground at the other. The husker impales the nut on the stick and twists it to tear open a section of husk. This process is repeated three or four times and can be done by a skilled person in 10-15 seconds or less. Husking requires considerable strength and effort; when there are large numbers of nuts to be processed, people generally opt to make cut copra, thus avoiding the husking step.

Copra is dried in the Marshalls under the sun, in natural-draft hot-air driers, or by a combination of the two methods. Sun drying is more common in the northern atolls where the conditions are more favorable, especially during the dry season. Cut kernels are placed on mats, pieces of corrugated roofint, or specially-constructed drying racks and left in the open air. The kernels must be covered at night and during rain showers, and protected from contamination with soil, sand or other extraneous matter. Adequate sun drying requires from three to eight days, depending on weather conditions and the quantity of copra being dried.

Hot-air driers are used when sun drying is not possible or when large quantities are being processed. Half-shells with kernels still attached, or previously cut kernels are placed on a raised perforated platform or rack. Hot air rises through to the coconut meat above. Burning fuel is usually coconut husks, shells, or both. The platform is usually covered with a thatch roof; the sides of the drier are closed to control air flow. Drying time ranges from two to five days depending on the efficiency of the drier, outside temperatures and humidity.

Sun dried copra is generally of better quality than copra made in a hot-air drier which may become smoky or scorched (coconut husks and shells generate a great deal of smoke). Regulating combustion and overall ventilation in copra driers is difficult.

Copra must be well dried to prevent mold and damage from insects during storage. Both drying methods yield good copra if used with considerable care and attention. However, copra is rarely graded or inspected when purchased on the outer islands, and the quality is often not as good as it could be.

Almost all copra in the Marshalls is produced in relatively small lots (several hundred to a few thousand nuts at a time). Most copra drying platforms in the Marshalls accommodate kernels from no more than a thousand

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nuts (enough to yield about three 100-pound bags of copra). The copra production methods throughout the Trust Territory are very similar to those described here.

COPRA MARKETING WITHIN THE MARSHALL ISLANDS

Copra is brought to one or two collection points within each atoll, picked up by a small ship, and transported to Majuro for processing. Transportation of the copra to the main collection point(s) in each atoll is no small matter. Anything from 20'-30' lagoon boats with inboard diesel engines to small outboard motor boats and sailing canoes might be used. The difficulty of the trip varies with the topography of the atoll, distance to be traveled, sailing conditions of the lagoon, and atoll fragmentation.

Copra from the outer islands is transported to Majuro for processing by small transport vessels locally called "field trip ships" which carry trade goods, cargo and passengers throughout the Marshalls. Four field trip ships are currently operated by the Republic of the Marshall Islands government. Privately-owned (and usually smaller) ships have occasionally operated similar service in recent years. A typical round-trip voyage from Majuro lasts two to three weeks and includes stops at four to six atolls. At each outer island stop, a licensed copra buyer weighs and buys copra from the island residents. The islanders then purchase supplies from the retailer's representative on the ship, usually an employee of one of the retail stores in Majuro. The ship's visit at each outer island stop normally lasts from 12 to 36 hours. The length of each stop and the duration of the entire trip is unpredictable because times of departure, arrival and transit of reef passes must be adjusted daiy to tides and weather conditions.

This unpredictability can compromise the quality of Marshallese copra, since it deteriorates if it is stored too long, and also results in occasional severe shortages of food and supplies on the outer islands. However, 19 runways have been constructed on the outer islands since 1980. These can accommodate small 14-16 passenger plans operated by the Airline of the Marshall Islands. This service is extremely valuable because formerly the field trip ships had sometimes to be diverted for medical evacuations.

DOMESTIC COPRA PROCESSING

When copra reaches Majuro, it is purchased by the Tobolar Copra Processing Plant, Inc. This plant produces coconut oil and copra meal. It was started in 1977 with assistance from the Marshall Islands government and is one of only two copra processing plants in the TTPI. The other is in Palau.

The Tobolar plant has a processing capacity of about 70 tons of copra per day (about 24,000 tons per year), roughly four times the Marshalls' annual production. Several purchases of copra from Kiribati in recent years have helped to more fully utilize this excess capacity. Prior to 1983, irregular electricity supply forced Tobolar to maintain its own generating equipment and there was a significant amount of down time. Now that a new power plant in Majuro provides adequate electricity, Tobolar should be able to easily process all Marshallese copra plus additional supplies from Kiribati or the Federated States of Micronesia.

Prior to 1977 and the construction of the Tobolar plant, most Marshallese copra was sold to Japanese processing plants. If the Tobolar plant operates efficiently, the Marshallese should be able to realize greater revenues from their coconut crop than previously. Coconut oil is more valuable and cheaper to ship than copra, and it can be stored longer. It can thus be withheld from the market when prices are unfavorable.

During its first years of operation, Tobolar was unable to market its copra meal for livestock food in the United States because the aflatoxin content of the meal exceeded U.S. standards. Aflatoxin is produced by mold growing on poorly dried copra and is a suspected carcinogen. The U.S. market has provided the best price for Marshallese copra meal in recent years, so the inability to sell to the U.S. means an economic loss for Tobolar. (Marshall Islands Journal, December 1981). Greater attention to proper drying techniques and more frequent quality inspections have since reduced the aflatoxin content in Marshallese copra meal, and it is now acceptable for sale in the United States (usually to dairies in Hawaii).

MARKET CHARACTERISTICS OF COCONUT PRODUCTS

PRODUCER PRICE VARIABILITY

Marshallese and other copra producers receive widely and frequently fluctuating prices for their product (Figure 7). For example, in the first five months of 1985, the price paid for a short ton of copra in Majuro dropped 42.5 percent (from $400 in January to $230 by May 24th (Marshall Islands Journal, May 24, 1985)). The slightly lower price paid on the outer islands (because of shipping costs) also dropped (from $370 to $200 per short ton). A study of 13 primary Pacific region commodities in the 1954-64 period showed that, while many products fluctuated, copra was the third most instable price-wise (Hawkins, Epstein and Gonzales, 1966).

WORLD MARKET CHARACTERISTICS

The Philippines usually accounts for 60 to 70 percent of total world exports of coconut oil and copra, the Marshalls only 0.3 percent. Therefore, Phillipines productivity can have a substantial impact on world prices.

Many primary vegetable oils that can be used interchangeably with coconut oil (corn, cottonseed, palm, peanut, safflower, soybean and sunflower oils) compete with coconut oil on the world market (Davey and Rogers, 1971; Beard, 1981). Substantial changes in the supply of any of these oils can influence the prices of the others.

Because of the tremendous growth of soybean production in the United States since the end of World War II, soybean oil currently dominates the entire market. In the United States (the largest consumer of vegetable oils in the world), soybean oil's share of the total edible vegetable oil consumed rose from 48 percent in 1950 to almost 80 percent in 1980 (Commodity Yearbook, 1981). Soybean supplies can respond quickly to price changes, while the supply of non-annual crops like copra and coconut oil cannot. (It normally takes seven years for a coconut palm to reach maturity and begin to bear fruit.) Thus, the world market for vegetable oils is influenced by many factors, and market prices are highly variable (Labys, 1973).

PRICE STABILIZATION EFFORTS

In 1950, the TTPI government established a Copra Stabilization Board to oversee copra marketing and administer a copra stabilization fund (Migvar, 1965). The fund was designed to buffer the instability of the world market. By withholding some copra revenue during times of high prices, funds were made available to supplement producer incomes when world prices declined sharply (Warren, 1954). This system operated in the TTPI until the Tobolar copra processing plant opened in 1977, and the Republic of the Marshall Islands formed its own Copra Stabilization Board.

There is no stabilization fund in the Marshalls. Tobolar sets the price it will pay to producers with the concurrence of the Copra Stabilization Board; buys all copra produced in the Marshalls; and is the sole exporter of coconut oil, copra meal and copra. Because Tobolar is a government-sanctioned monopoly, it is critically important that it operate efficiently and in the best interests of the Marshallese people. Therefore, it is proper for the Copra Stabilization Board to have clear and direct oversight responsibility for Tobolar.

COOPERATIVE DEVELOPMENT

During the last 15 years, the Marshall Island government has encouraged the establishment of consumer and producer cooperatives on the outer islands. The objective was to eliminate middlemen and provide a way for outer island producers to sell their copra on a daily basis without having to wait for the field trip ship. This seemed like a good idea, but it has been extremely difficult to implement. Poor financial management and the inability of most Marshallese to refuse credit to their relatives have caused most cooperatives to fail. Of the 22 outer island cooperatives once in operation, only a few remain (Department of Defense, 1984).

HANDICRAFT MARKETING

Palm product handicrafts are marketed by a cooperative headquartered in Majuro. This cooperative has grown over many years, and it successfully provides an otherwise unavailable outlet for outer island crafts. It is probably possible to expand handicraft exports to Hawaii and mainland U.S. markets, but financial returns to individual producers are usually minimal. Contract offers for large quantities of handicraft items (at fixed prices) have been refused by Marshallese in the past. Apparently the labor required to produce the desired volume of handicrafts was deemed excessive.

RESEARCH AND EXTENSION IN THE COCONUT INDUSTRY

MARSHALL ISLANDS RESEARCH AND EXTENSION

Very little coconut research has been conducted in the Marshalls, although a small number of agricultural extension workers have tried to help increase copra production. Modest coconut replanting and grove rehabilitation efforts have been made since at least the late 1960s. Rat control programs have also been implemented on some islands.

Early extension efforts focused on the selection of large palms as a source of seednuts since trees grown from large nuts would, it was thought, yield large nuts (Sproat and Migvar, 1968). In later efforts, the Thifow variety of seednut (brought to the Marshalls from Yap) was used. Thinning of overcrowded groves, proper spacing of seedlings, composting at planting, brush control and removal of senile palms were also emphasized (Migvar, 1965b).

Sodium arsenite was used to kill senile palms until 1971 when U.S. environmental protection regulations banned this practice. Several people from Utirik Atoll, where I worked as an agricultural extension agent from 19069 to 1971, have asked of sodium arsenite applications could have caused the severe decline of arrowroot plants (*Tacca leontotopetaloloides*) in the coconut groves. Such questions have not been examined in detail in the Marshalls.

Research is also clearly needed on the effects of fertilization on ground water quality and coconut palm yields; consumer acceptance of coconut oil soaps and shortening; and techniques to reduce bacterial growth and aflatoxin development during drying. The effects on productivity of tree spacing, sunlight and soil moisture should also be studied. Spacing palms so their fronds overlap would reduce sunlight but it might also conserve soil moisture. The expertise of the Taiwanese agricultural mission could be utilized to examine some of these questions.

RESEARCH AND EXTENSION ELSEWHERE

Some research and development work on local manufacture of coconut oil soaps, shampoo, hair and body oil, and shortening has been done at the Ponape Agriculture and Trade School (PATS). Cooperative work along these lines between the Marshalls and Ponape could benefit both. PATS needs assistance with marketing regulations and product labeling requirements for export to the United States.

The Marshalls should also be able to benefit from the research programs of the major coconut-producing countries; someone in the Marshalls should be paying attention to the scope and variety of the work being done. In December of 1976, for example, 80 research papers were presented to over 320 delegates of eight nations at the International Symposium on Coconut Research and Development in India. The topics addressed included: genetics and breeding; agronomy and soil sciences; biochemistry and physiology; technology; diseases and pests; and development programs (Nayar, 1983).

Recent research in farming systems and agroforestry should also be beneficial to the Marshallese. Topics such as intercropping nitrogen-fixing plants and small-holder farming practices are especially relevant (Liyanage, Tejwani and Nair, 1984). Research on related crops like oil palms (Elaeis guineensis) may also yield useful information for coconut cultivation (Schumacher, 1983; Agamuthu and Broughton, 1985).

ANALYSIS OF ALTERNATIVE USES OF COCONUT PRODUCTS

Only a few of the many commercial uses for coconut products can be economically developed in the Marshall Islands. Although all Marshallese copra is currently processed into crude coconut oil and copra meal for export by the Tobolar Copra Processing Plant, Inc., copra meal could also be incorporated into swine and poultry feed, and coconut oil could be used to make soap and cooking oil.

FOOD PRODUCTS FROM COCONUT OIL

If refined, Tobolar's coconut oil could be used as an ingredient in food products. Refining is certainly technically feasible, but a recent U.N. study indicated that the total cost of producing cooking oil would be prohibitive, given the price of imported cooking oil. An import tax of 75 percent would be necessary to make the locally-produced cooking oil competitive with imported oils (Santhiapillai, 1980).

COCONUT OIL SOAP

Production of toilet soap comparable to imported brands (containing 79 percent total fatty matter) was deemed too expensive for the relatively small consumer market in the Marshalls. A projected 75 percent tax on imported toilet soap would be required for even a lower quality locally-produced soal to assume 50 percent of the existing toilet soap market. Economically competitive production of laundry soap would require a 50 percent tax on imported laundry soap and a 75 percent tax on imported laundry powders.

DOMESTIC USE OF COPRA MEAL FOR ANIMAL FEED

Some of Tobolar's output of copra meal (which has a high fatty content) could be used domestically as a non-primary ingredient in swine and poultry feed. Feeding experiments with poultry have shown that 20 percent copra meal is the maximum for good results with young growing birds, and a limit of 10 percent is better for laying hens (Thampan, 1981). Most feed ingredients would still need to be imported, and this might be as costly as importing a complete feed. Furthermore, a small-scale batch feed mill on Majuro could have higher per-unit costs than larger foreign mills. Even if locally produced feed could be sold for the same price as imported feed, the Marshalls would gain mostly from employment created by the construction and operation of the feed mill. As always, the aflatoxin content of the copra meal would have to be watched. A more practical and simpler approach might be for poultry producers to use some local meal as an extender for imported feed.

To summarize, the small size of the Marshallese market will simply not support most manufacturing and processing operations at an efficient scale. It is usually cheaper to import finished products from large-scale foreign manufacturers than to import raw materials and finish them locally. High shipping costs, the scarcity of locally available raw materials, the high cost of maintaining mechanical equipment in the harsh atoll environment, and difficulty in obtaining spare parts and a continuous supply of raw materials are some of the major obstacles to local manufacturing and processing. Inadequate or unreliable supplies of water and electricity can also be problematic.

DESICCATED COCONUT

Production of desiccated coconut for export could be profitable. In the Kingdom of Tonga in 1984, I observed the operation of a desiccated coconut plant which had technology readily transferable to the Marshall Islands (Figures 8-11). Husking, removing the shells, paring the kernels, loading husks and shells into the drying furnaces, and grading and bagging the finished product were all done manually. Shredding, drying, sifting and separating the desiccated coconut by size was done mechanically. Almost all the whole nuts purchased were used. About half of the husks and shells were used as fuel for the driers; the remainder were sold to householders for fuel (Pacific Energy Programme, 1982a). Kernel parings and unsuitable portions of meat were made into copra. Only the coconut water within kernels was lost, and some of what was used to rinse debris from the pared meat.

Tonga's coconut producers seemed to prefer supplying whole nuts to the desiccated coconut plant to making copra, since they were being paid only slightly less per nut than what they would receive for the copra from one nut. Tonga's production and export of a product with higher value than copra and coconut oil resulted in economic benefits both to coconut producers and the employees of the desiccated coconut plant.

It might be possible for the Marshall Islands to realize similar benefits from producing desiccated coconut. Certainly an adequate supply of nuts is available on Majuro, which produced an average of 375 short tons of copra (about 2.25 million nuts worth) between 1978 and 1983. Marshallese people are also familiar with the desiccating process; very little training would be needed. On the other hand, shipping difficulties may prevent the Marshallese product from reaching buyers in a timely manner, and the perishability of desiccated coconut must be considered. (Tonga is the last island stop on the South Pacific Forum shipping routes to New Zealand or Australia, and its produce reaches major ports in only a few days on a very regular basis.) Marshallese labor is also among the costliest in the Pacific region; thus, Marshallese desiccated coconut might not be competitive economically. Since desiccated coconut would be an excellent complementary product to copra, however, its potential should be evaluated in the Marshalls.

LIQUID COCONUT PRODUCTS

Canned or bottled coconut water, milk, cream or sap (toddy) are produced in some coconut-producing areas, but expensive, sophisticated equipment is required, and the necessary sanitary and bacteriological controls would be extremely difficult to implement in the Marshalls. Containers would have to be imported. Majuro's fresh water supplies are currently quite limited and water use is frequently restricted. This would make it very difficult to operate an efficient canning or bottling plant (Santhiapillai, 1980).

Recent developments in paper packaging and ultra-heat treatment to extend the shelf life of dairy products, and major improvements in coconut aqueous processing could be applicable to the coconut industry in the future. However, many of these methods (i.e., of oily, proteinaceous, fibrous and water-soluble fractions) are currently too expensive and complex for developing nations like the Marshall Islands (Hegenmaier, 1980).

A much simpler approach would be to encourage people to drink coconut milk directly instead of imported soft drinks. This could yield both economic and nutritional benefits. Since, at current prices, each nut yields approximately 3.8 cents worth of copra, 16 coconuts must be processed to cover the 60-cent cost of one imported soft drink. The economics of that transaction are strikingly clear and were highlighted along with nutritional data in a successful campaign in Yap to increase consumption of coconuts as opposed to Coca-Cola. The 18-month educational and advertising campaign reduced expenditures on imported soft drinks from $450,216 in 1974 to $198,447 in 1975. Only $88,478 was spent on soft drinks in the first three quarters of 1976. While the retail price of soft drinks rose from 40 to 50 cents between 1974 and 1976, fresh coconuts were selling at 20 to 25 cents (Nancy Rody, personal communication, March 14, 1983). This is an excellent example of direct import substitution which could be emulated in the Marshalls.

COCONUT HUSKS AND SHELLS AS FUEL

A number of coconut palm products have traditionally served as primary fuel sources in the Marshall Islands. Coconut husks and shells have been the major Marshallese cooking fuel for centuries; on the outer islands most cooking is done over coconut husk and shell fires. Husks and shells also fuel copra driers; distillation of salt from sea water; melting of lead for fishing weights; and bleaching of the pandanus leaves used in woven sleeping mats and fine handicraft items. Torches made from dried palm fronds are used for night fishing and to burn the hair off butchered pigs. Alternative fuel sources would be very costly.

The use of coconut palm biomass to fuel larger-scale activities such as steam generation is technically possible (Feinstein, 1984). The difficulty in the Marshalls lies in collecting, storing and handling the quantities needed for such uses. Husks could be gathered in large quantities on Majuro Atoll (with some difficulty). However, husk shipments to Majuro from the outer islands are simply not possible given current shipping capacity and the sheer volume of whole nuts or husks (this would be ten or more times greater than the volume of copra from an equivalent number of nuts). In 1984, each of the Marshall Islands' four field trip ships cost over $205,000 to operate (Department of Defense, 1984). The costs of expanding service and of acquiring new ships would be prohibitive.

If husks were gathered in large quantities for fuel, moreover, they would not be available for decay and return to the soil. Marshall Islands soils are very sandy and organically poor, and loss of this nutrient input could have a negative impact. Soil scientists should assess the exact magnitude and significance of this impact; given the marginal quality of the atoll soils, caution and careful consideration seem prudent.

COCONUT OIL AS FUEL

The use of coconut oil as a substitute for diesel fuel is being examined in a number of countries. Tests conducted in Western Samoa have shown that coconut oil can be used alone or in a blend with diesel fuel without affecting engine power. Particulate matter in the coconut oil, however, clogged fuel filters after a few hours of operation. Injector coking and residue accumulation on other internal parts were expected to be serious problems (Pacific Energy Programme, 1982b). Further research may reveal a way of avoiding these by pretreatment of the coconut oil, modification of engine design, fuel blending with petroleum products or ethanol, or a combination of approaches. Maintenance of mechanical equipment is always a problem on remote islands, but if these difficulties can be resolved, the Marshalls and other coconut oil-producing countries could achieve substantial savings on imported fuel, savings that would surpass the current earnings from coconut exports. It may also be possible to use coconut oil/ethanol blends as a substitute for kerosene in cooking stoves and lamps for household use.

Successful coconut oil-fueled engines could also be utilized for power generation, thus eliminating the supply problems inherent in basing petroleum-fueled generating systems on remote islands. A 1983 cost comparison in the Marshalls showed that a 10KW coconut oil-fueled generator-expeller combination would be cheaper than a photovoltaic system of the same size (Kasper, 1983). Neither system, however, is affordable by outer island standards, and they were not compared to standard diesel-powered systems. Moreover, the comparison did not account for fluctuations of coconut oil prices or declining costs for photovoltaic systems (as the efficiency of that technology improves). These factors could drastically affect the comparison.

COCONUT STEMS AS LUMBER

Lumber made from coconut palm trunks is used to a limited extent for construction in the Marshalls. Commercial milling and processing of such lumber wqould be difficult because raw materials are so widely dispersed; shipments of trunks to Majuro would be prohibitively expensive. It might pay to barge a portable sawmill from atoll to atoll if substantial numbers of old trees were being felled as part of the coconut replanting program. The timber could be used to construct copra warehouses on the outer islands. The disposal and/or utilization of senile palm stems is a concern throughout the Pacific region, since decaying stems are the favorite incubation material of rhinoceros beetles (Oryctes rhinocerus), and can provide habitat for other harmful insects as well (Davis and Sudasrip, 1982). Fortunately, rhinoceros beetles have not spread to the Marshalls, and it is important to prevent them from gaining a foothold.

Fiji has examined several options: reducing stems to ash for fertilizer; and carbonization of stems into charcoal, using them for structural timber and decorative furniture (Richolson, 1980). Studies on Fiji and elsewhere in the region may be useful to the Marshalls, and their progress should be closely followed.

PRODUCTION OF CHARCOAL

Coconut shell charcoal has been mentioned frequently as a possible byproduct of copra making in the Marshalls. High shipping costs, relatively high labor costs, and small potential output would make centralized processing prohibitively expensive, although decentralized processing on the outer islands (where there is excess labor) might be possible. Unfortunately, few Marshallese are familiar with charcoal-making techniques, most of which have considerable drawbacks (i.e., high smoke emission and relatively small output). Tests in the Philippines showed that charcoal made in metal drums weighed only 24 percent of the initial charge of coconut shells (Hagenmaier, 1980). Further development of processing methods and a large extension effort to demonstrate any effective techniques developed would be needed to establish charcoal making in the Marshalls.

COCONUT FIBERS

Somewhat greater use of coconut fibers could be encouraged in the Marshalls for handicrafts, sennit, doormats, brushes, and other products.

Some aspects of coir processing ahve been mechanized in larger producing countries, like India. One simple technology that could be transferred to the Marshalls is the spinning wheel (Thampan, 1981). This could greatly reduce the amount of labor required to spin sennit from coir in the Marshalls.

Like many other potentially productive enterprises, those based on coconut fibers are unlikely to be economical or attractive given high labor costs and the increasing availability of synthetic materials for the same uses. However, coconut fibers are still extremely valuable for outer island people isolated from manufactured products and/ior unable to afford them.

CONCLUSIONS AND RECOMMENDATIONS

EVALUATION OF ALTERNATIVE USES OF COCONUT PRODUCTS

This paper has profiled the Marshallese coconut industry and some of the salient characteristics of the world market for coconut products. A number of alternative uses of coconut products have been examined in light of existing conditions in the Marshalls and the constraints they place on development. Some might make significant contributions to the Marshallese economy, while others are less likely or unlikely to (Table 8).

LIKELY ECONOMIC IMPACT

Implementation of Category A activities (Table 8) would probably only modestly increase income for copra producers on Majuro. (The impact on outer island producers would proably be negligible.) Small increases in government revenues would follow.

While much harder to achieve, successful development of the Category B activities (Table 8) would also increase copra producer incomes only modestly. Substantial savings for the government and private consumers would likely result from fuel import substitutions.

Not even successful implementation of all these activities could, however, compensate for the current levels of priavte and public expenditures. On most Pacific island nations, government operations and services cost far more than the tax revenues bring in, and the Republic of the Marshall Islands is no exception. In 1976, the Marshall Islands government planning office assumed a tripling of both copra production (to 18,480 short tons per year) and the local tax rate on copra (to six percent), and an extremely high copra price (22 cents per pound), to project an annual government revenue of $486,000. Unfortunately, the government's annual expenditure level at that time was $8.9 million, and actual government revenues are well below that optimistic projection. The average price for outer island copra from 1979-

1983 was 12.4 cents per pound, and average annual production during this period was 6,227.12 tons. With the actual two percent tax rate, this yielded gross annual revenues of about $31,148 to the government from 1978 to 1981. It might have cost that much or more to collect these taxes.

RECOMMENDED ACTIONS FOR U.S. GOVERNMENT AGENCIES

Marshallese people and institutions must be responsible for most actions to develop the Marshallese coconut industry. However, U.S. institutions can fund research reviews, and help assess the relevance of research in other countries to the Marshalls. This should be a primary objective of the U.S. Congress. In addition to the research needs described in the "Marshall Islands Research and Extension" section above, some attention should be given to identifying dwarf, early-bearing varieties and to possible technological improvements (such as small-scale spinning machines for making sennit). Extension activities should be given greater support as well, especially if new technologies (i.e., for charcoal production) are found to be economically viable.

The U.S. Department of Commerce could assist by clearly publicizing the requirements and regulations which apply to marketing various coconut products in the United States. I have seen coconut oil bottled in Ponape as "pure coconut oil" even though it obviously contained perfume.

RECOMMENDED ACTIONS FOR MARSHALLESE INSTITUTIONS

The current coconut planting program should be continued with one modification. Triangular spacing of the seedlings should replace square spacing. Even without changing the linear distance between trees, this simple modification would place 16 percent more trees in a given area (64 trees per acre instead of 55; 158 trees per hectare instead of 137). Thus, a 16 percent increase in production could be achieved with one simple change.

Tobolar could more actively promote copra production by publicizing the annual production totals for each atoll more effectively. The 1984 production totals were given only nominal coverage in the Marshalls' weekly newspaper (Figure 12). Atolls achieving the greatest percentage increases in production over the previous year could be given special recognition.

The *Marshall Islands Journal* could publish annual production totals and ensure that that issue of the paper is widely distributed to the outer islands (perhaps by air). The *Journal* could also profile skilled producers of handicraft items. The Alele Museum is already encouraging continuation of handicraft skills.

With increased publicity and promotion, there could conceivably develop a national competition among the atolls. Even if informal, this could inspire greater productive efforts on remote islets.

Marshall Islands High School could develop a curriculum for grove management and copra making and processing. This would also encourage a new generation of Marshallese to accept improved cultivation techniques and to have greater appreciation for the coconut industry's role in their economy. The Ministry of Education could sponsor essay contests and other activities to increase public awareness of the value of the coconut industry.

Given the Tobolar Copra Processing Plant's unique position as a government-sanctioned monopsony, and the relatively small scale of Marshallese copra production, it is probably not possible to have competing processors and marketers. Thus, it is imperative for the Marshall Islands legislature (the Nitijela) to carefully oversee Tobolar's activities and pricing policies. This can be done directly or through the Copra Stabilization Board; in either case, it must be more than a formality.

Finally, the benefits of intergovernmental cooperation should be actively pursued. For example, the Republic of the Marshall Islands and the Federated States of Micronesia could work cooperatively on processing techniques and marketing arrangements for coconut oil products. The Taiwanese agricultural mission in the Marshalls could also be encouraged to expand its research to include the Marshallese coconut industry.

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Appendix A

COPRA PRODUCTIVITY COMPARISON OF SINGLE ISLANDS AND ATOLLS IN THE MARSHALL ISLANDS, 1978-83

Productivity of the four inhabited single islands (Jabot, Kili, Lib and Mejit) is calculated in the following manner:

(total production of 1764.72 tons)/(6 years)/(1062.4 acres)

= 0.2768 short tons per acre.

Likewise, for the twenty inhabited atolls:

(total production of 35403.62 tons)/(6 years)/(43596.8 acres)

= 0.1353 short tons per acre.

Therefore, copra productivity on the single islands was 2.045 times as great as productivity on the inhabited atolls during the six-year period from 1978 through 1983.

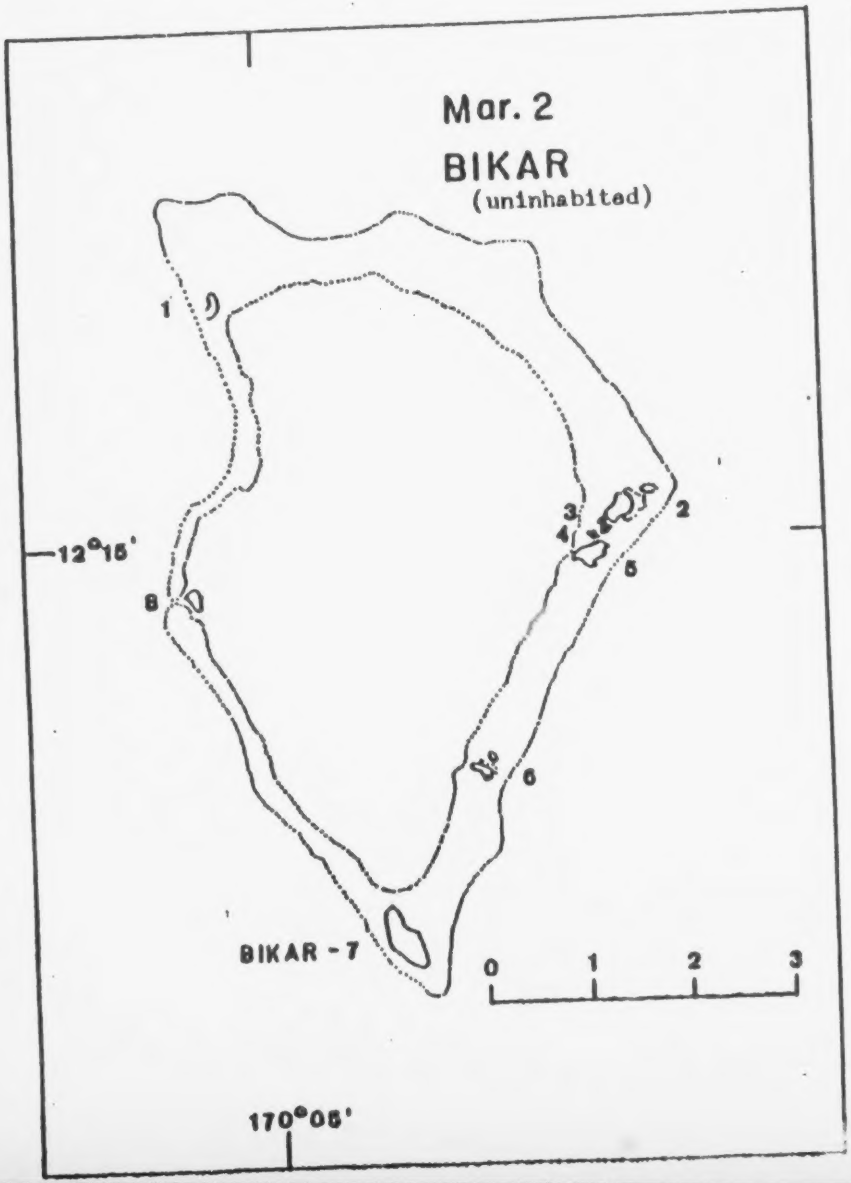
(Data for these calculations were taken from Tables 6 and 7, pages 20 and 21, in the text.)

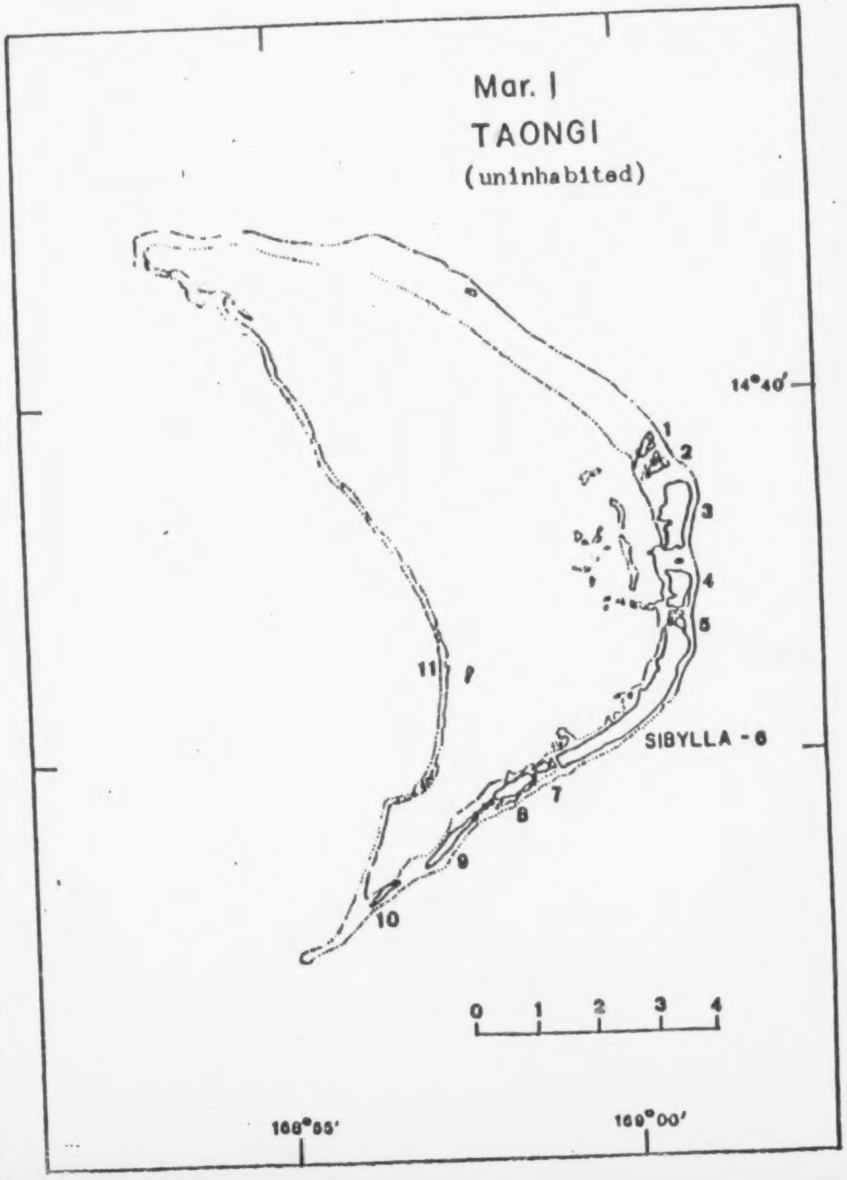
Appendix B

MAPS OF THE MARSHALL ISLANDS

This appendix includes maps of every atoll and island in the Marshalls group (Bryan, 1971). The extreme fragmentation of land area is clearly evident. Solid lines denote island boundaries. Dotted lines show the area of coral reef which is at or slightly below sea level.

Note: the maps are drawn at different scales.

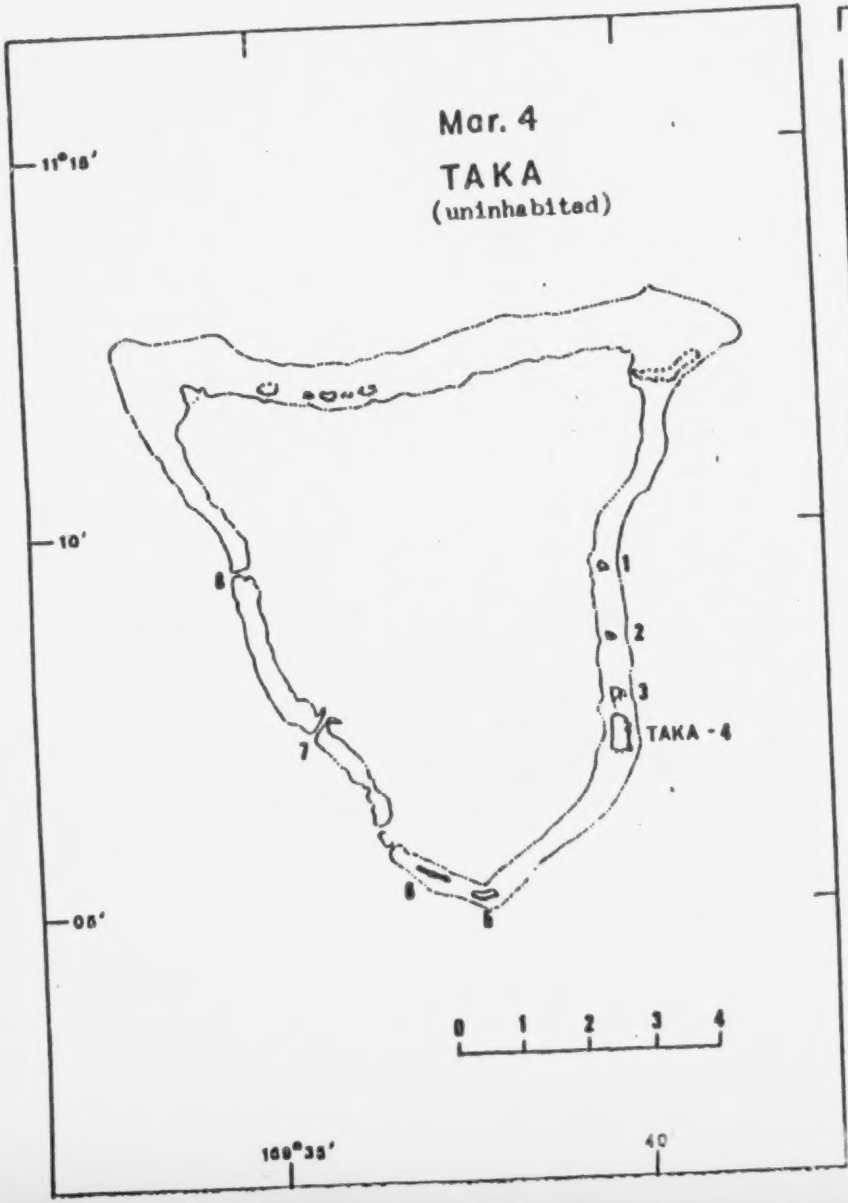

Mar. 2
BIKAR
(uninhabited)
1
2
3
4
5
6
8
BIKAR - 7
12°15'
170°05'
0
1
2
3


Mar. 1
TAONGI
(uninhabited)
14°40'
1
2
3
4
5
SIBYLLA - 6
7
8
9
10
11
0
1
2
3
4
168°55'
169°00'

Mar. 4

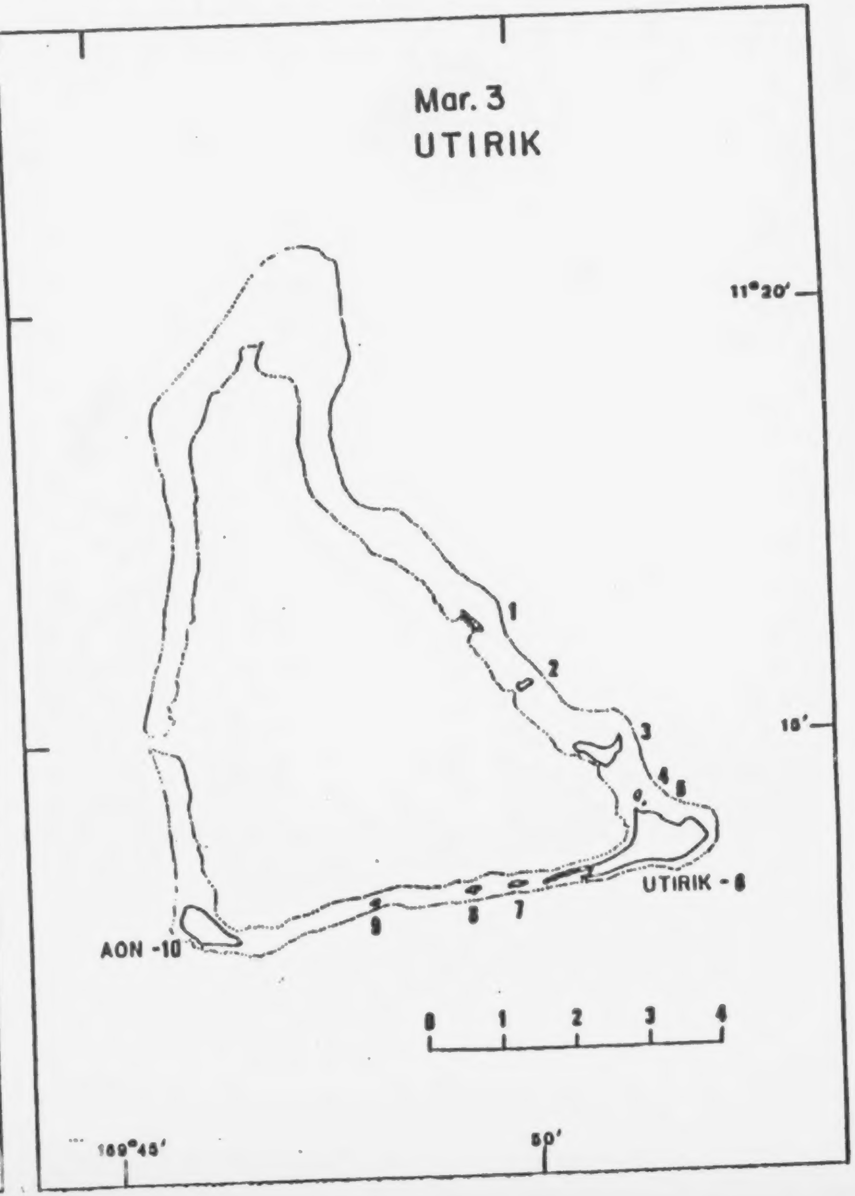
TAKA

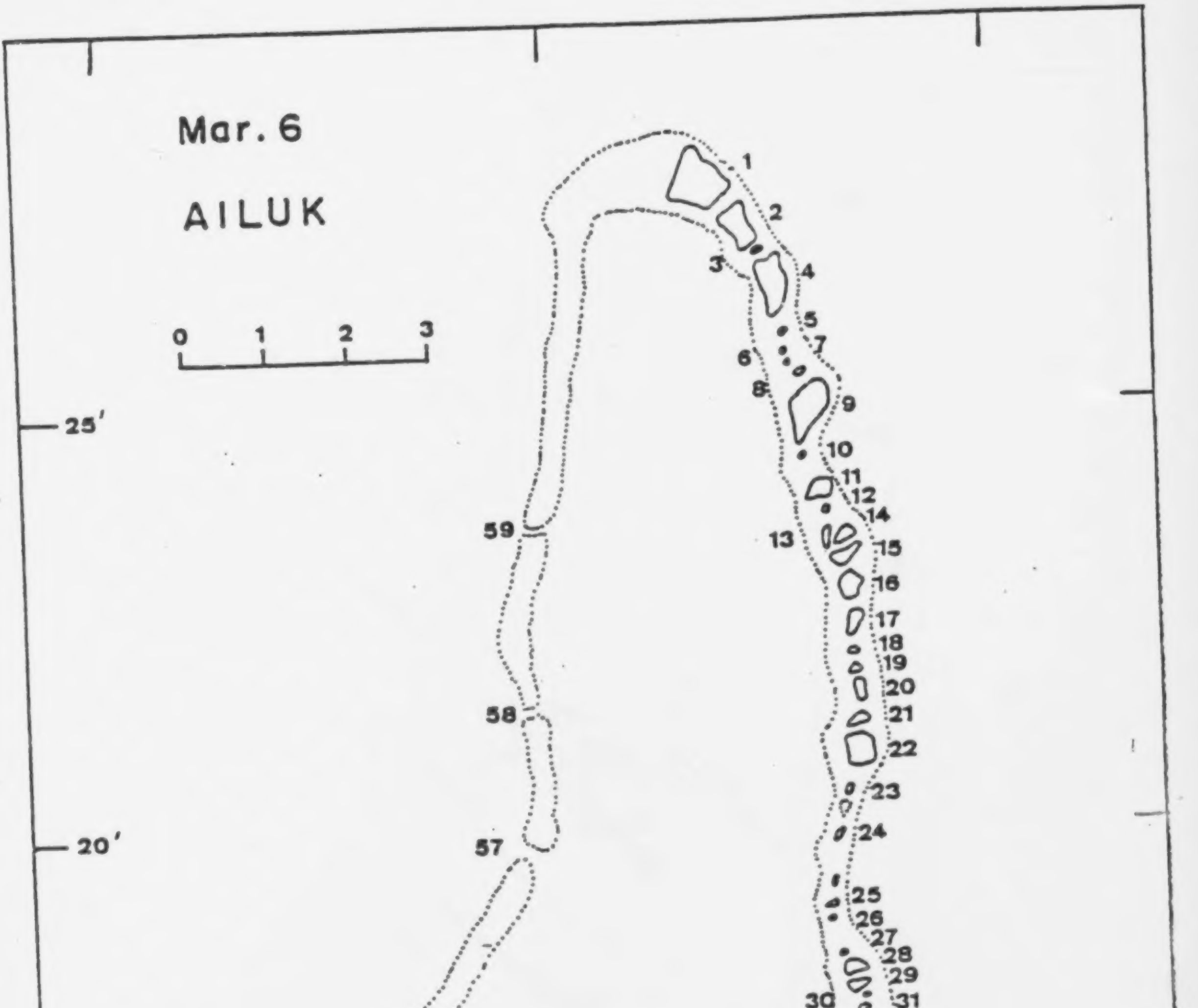
(uninhabited)


11°15'
10'
05'
169°35'
40
1
2
3
TAKA - 4
5
6
7
8
0
1
2
3
4

Mar. 3

UTIRIK


11°20'
15'
169°45'
50'
1
2
3
4
5
UTIRIK - 6
7
8
9
AON - 10
0
1
2
3
4


Mar. 6
AILUK
0
1
2
3
25'
20'
10° 15'
169°50'
55'
170°00'
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
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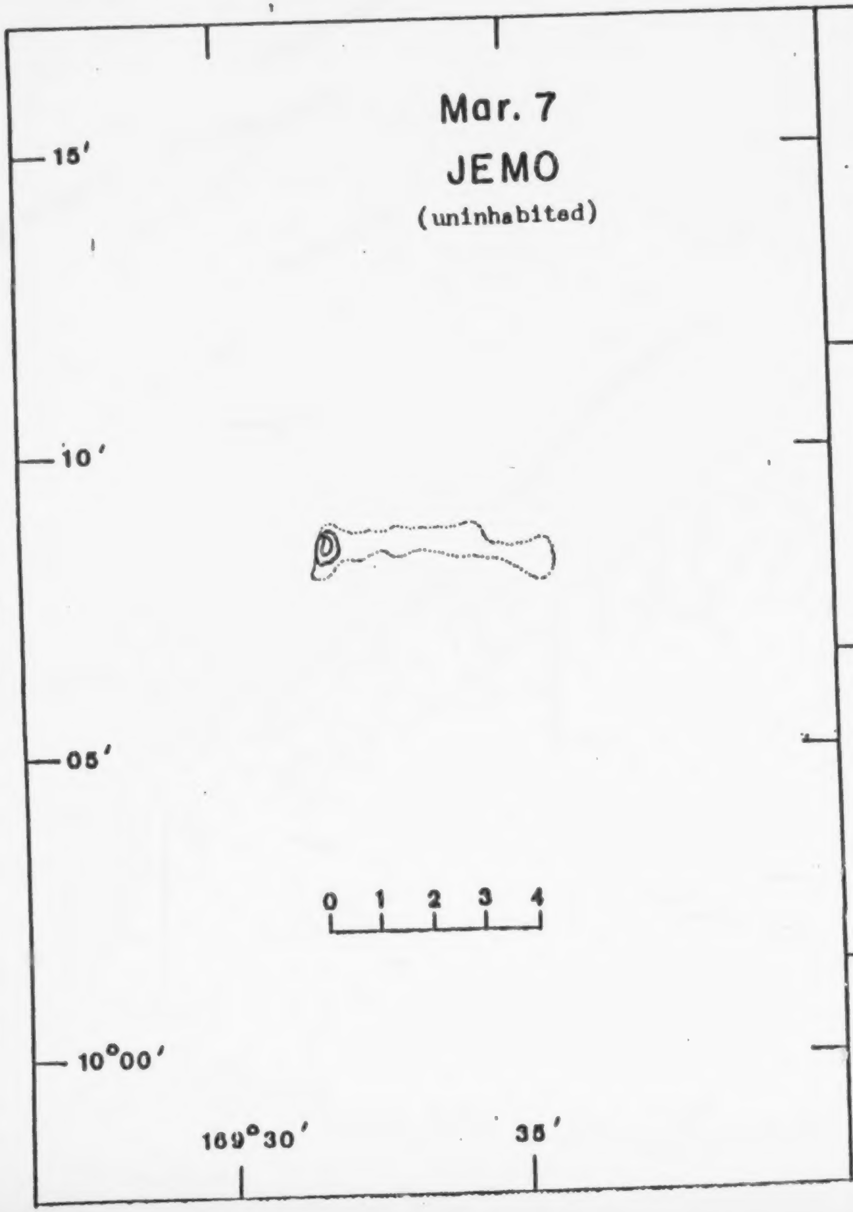
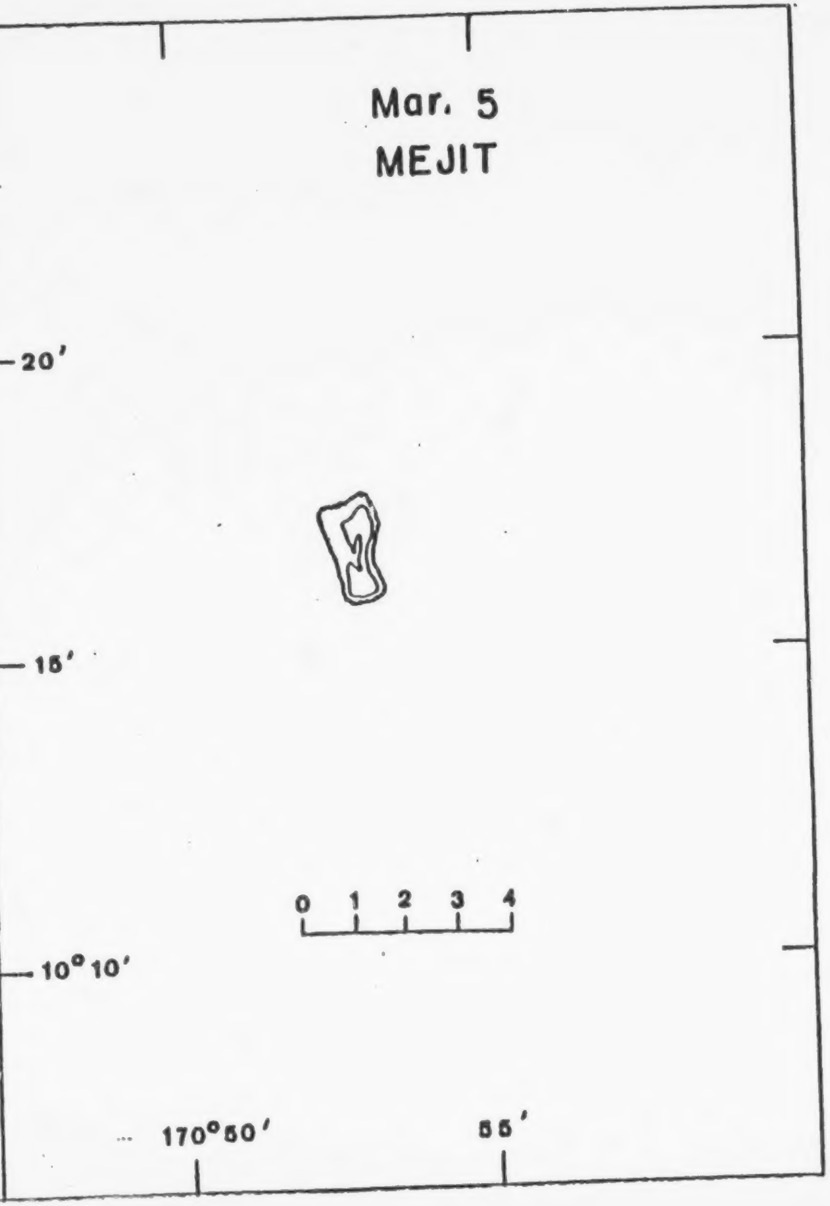
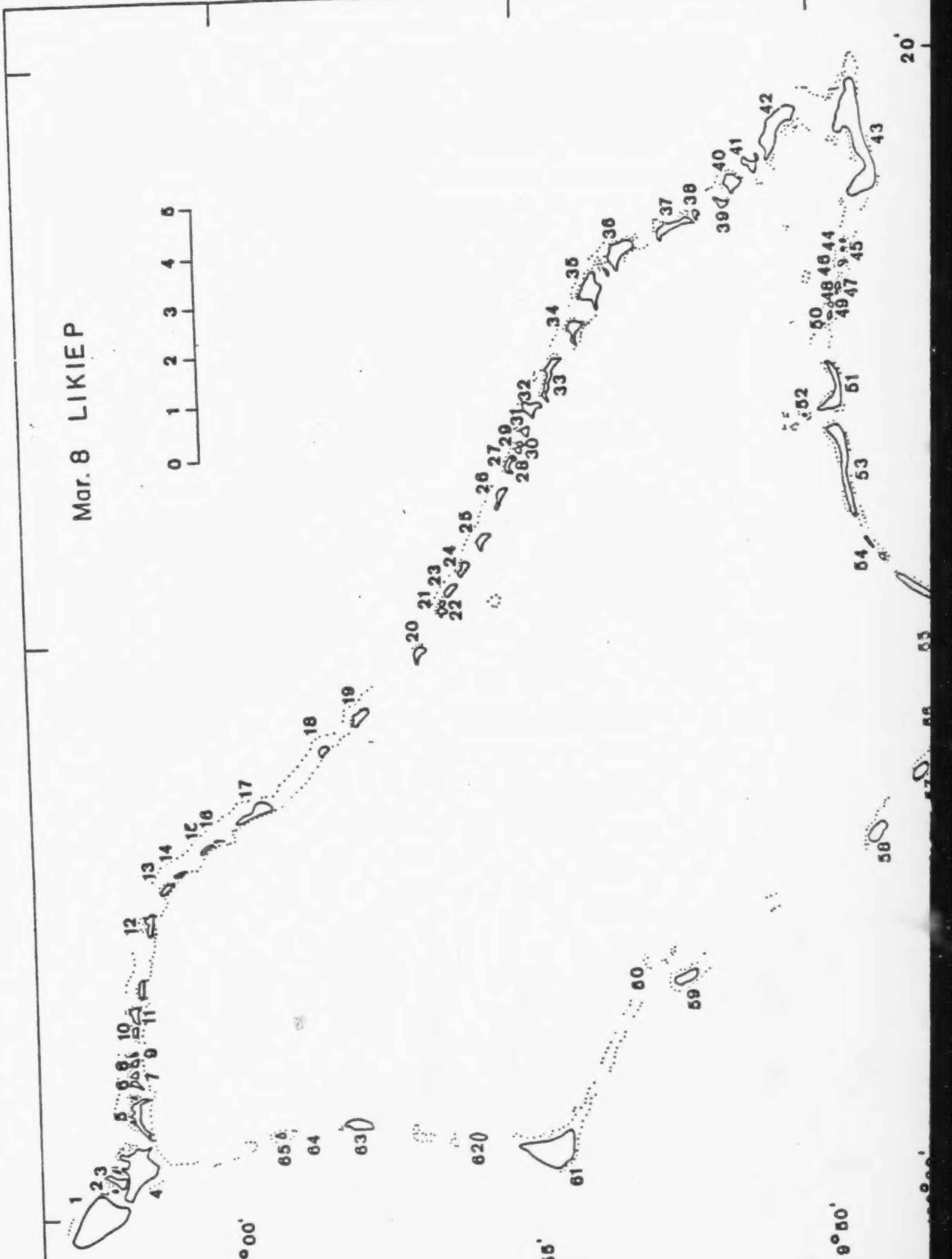

Mar. 7
JEMO
(uninhabited)
15'
10'
05'
10°00'
0 1 2 3 4
169°30'
35'


Mar. 5
MEJIT
20'
15'
10°10'
0 1 2 3 4
170°50'
55'


Mar. 8 LIKIEP
0
1
2
3
4
5
10°00'
55'
9°50'
20'
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
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31
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44
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60
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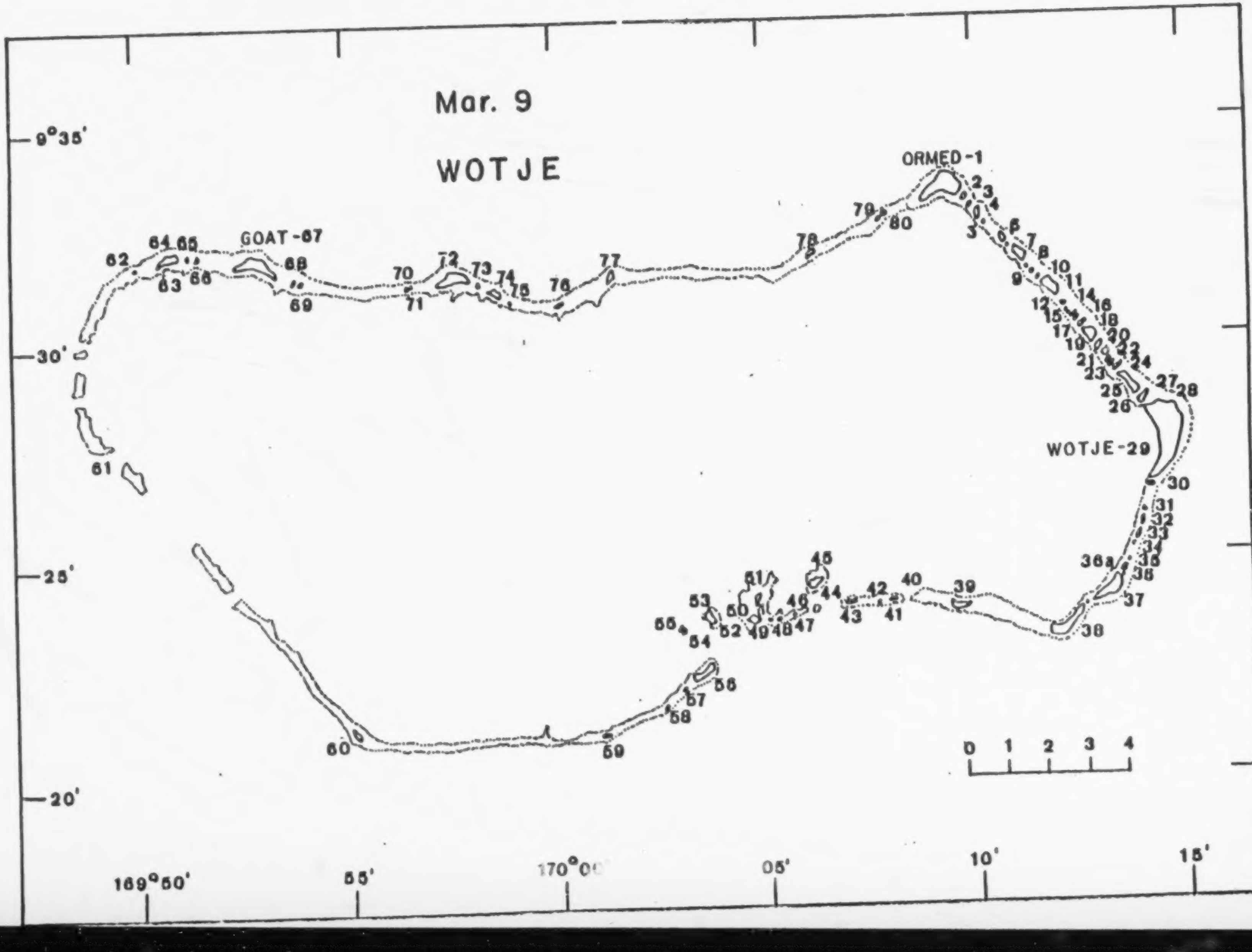
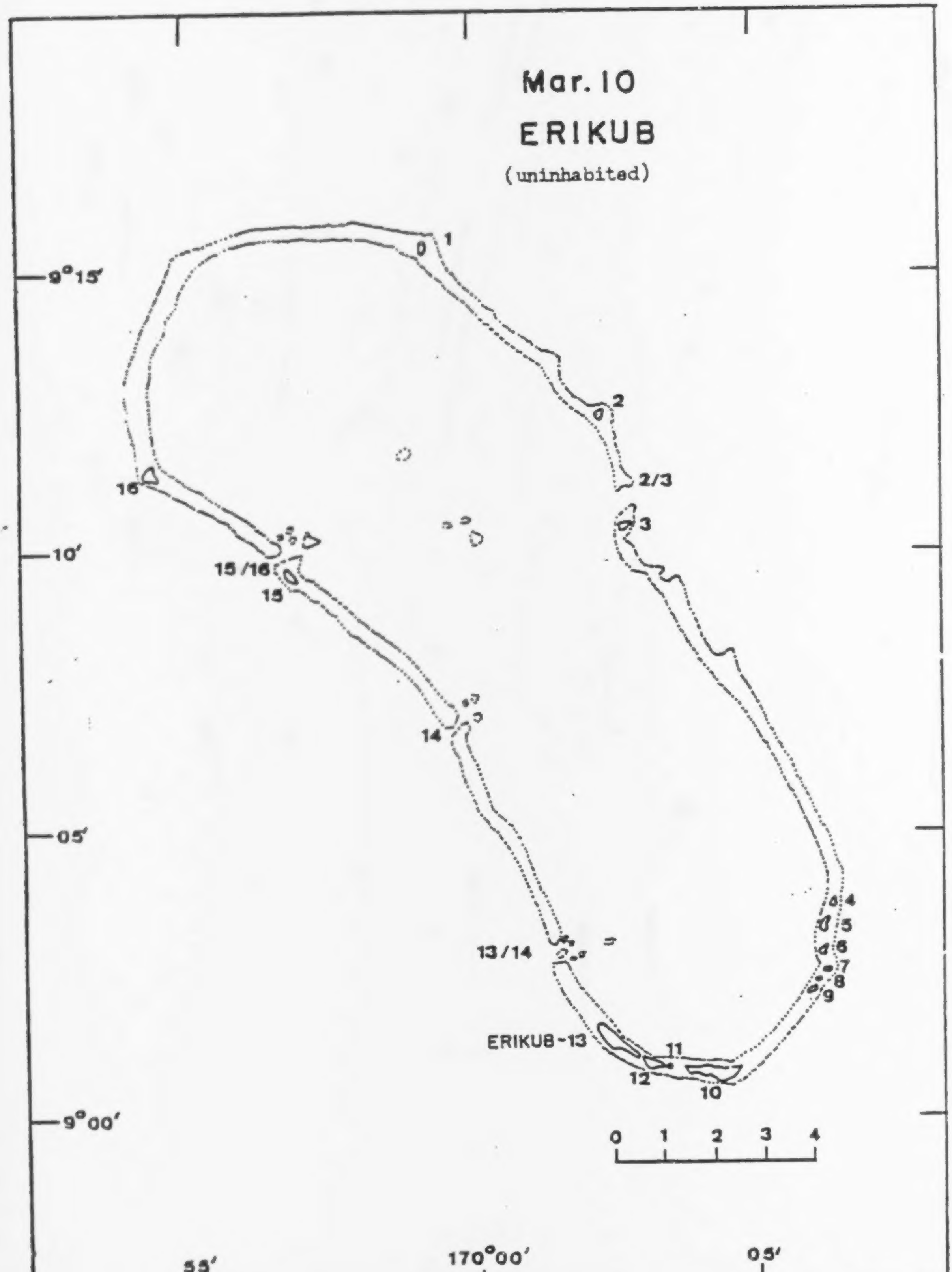
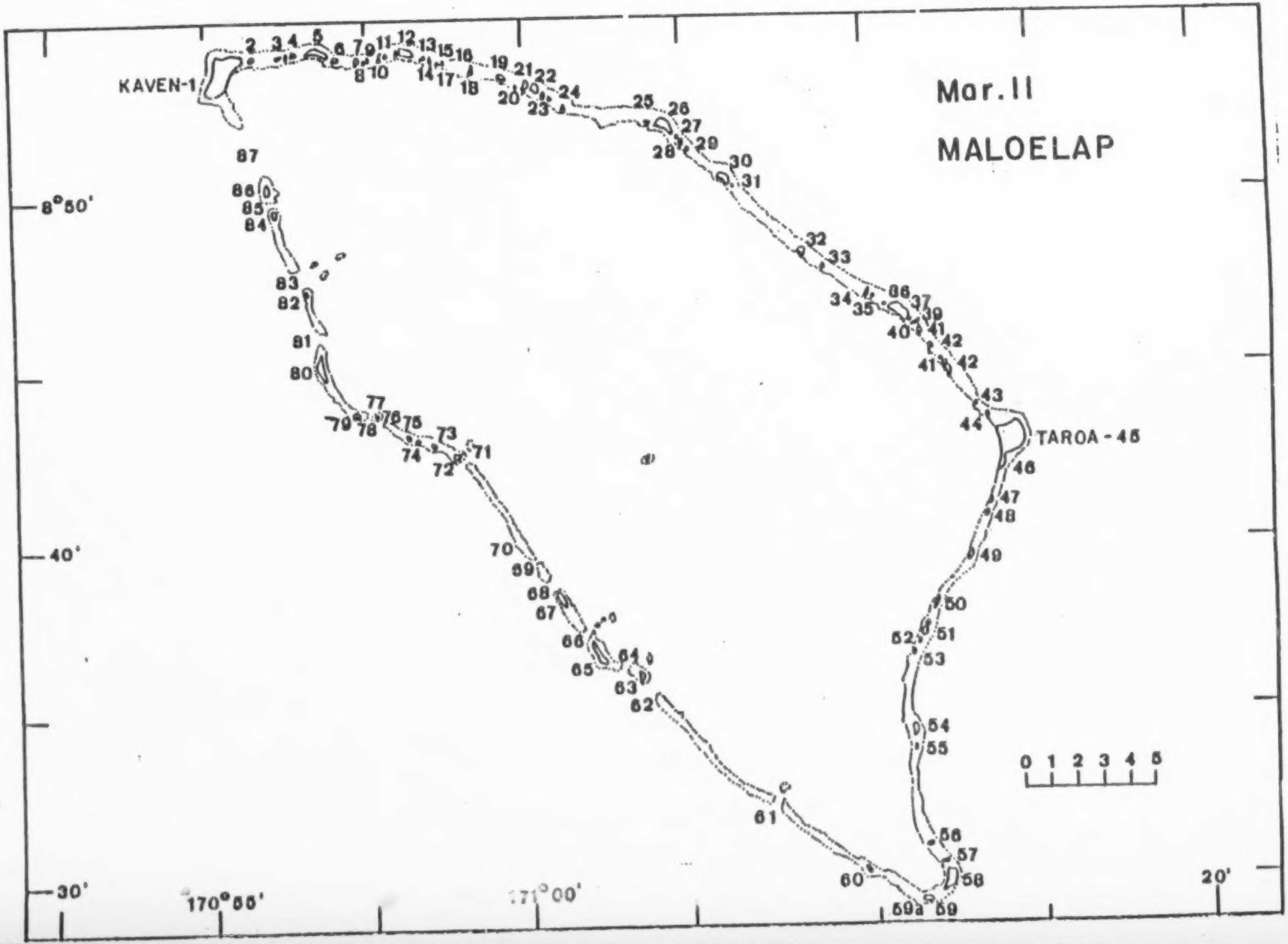
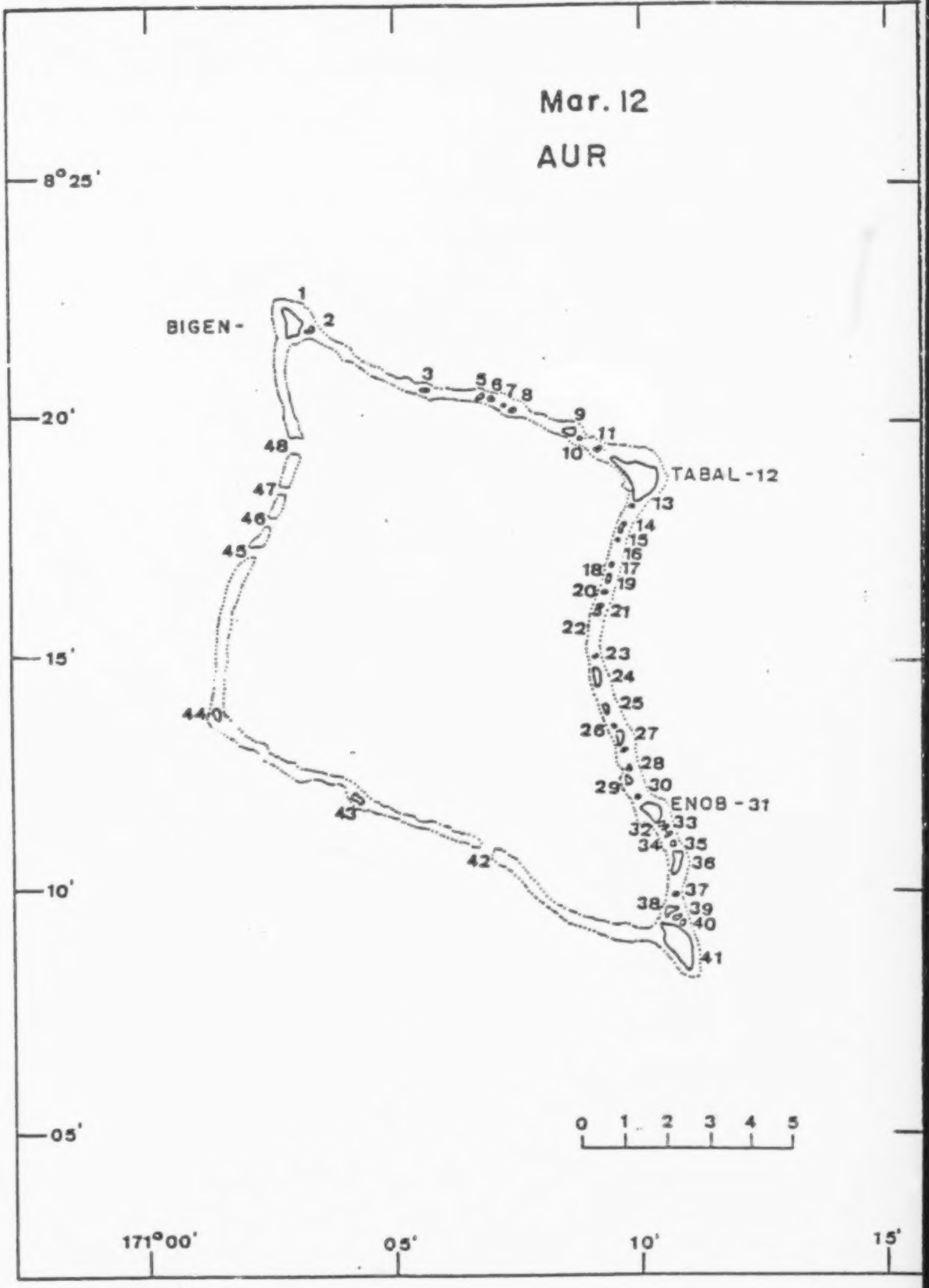
62
63
64
65


Mar. 9
WOTJE
ORMED-1
GOAT-67
WOTJE-29
9°35'
30'
25'
20'
169°50'
55'
170°00'
05'
10'
15'
0 1 2 3 4
1 2 3 4 5 6 7 8 9 10 11 12 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 30 31 32 33 34 35 36 36a 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 68 69 70 71 72 73 74 75 76 77 78 79 80


Mar. 10
ERIKUB
(uninhabited)
1
2
2/3
3
4
5
6
7
8
9
10
11
12
ERIKUB-13
13/14
14
15
15/16
16
9°15′
10′
05′
9°00′
55′
170°00′
05′
0
1
2
3
4


Mar. 11
MALOELAP
KAVEN-1
TAROA-45
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 39 40 41 42 43 44 46 47 48 49 50 51 52 53 54 55 56 57 58 59 59a 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87
0 1 2 3 4 5
8°50'
40'
30'
170°55'
171°00'
20'


Mar. 12
AUR
8°25'
20'
15'
10'
05'
171°00'
05'
10'
15'
BIGEN-
TABAL-12
ENOB-31
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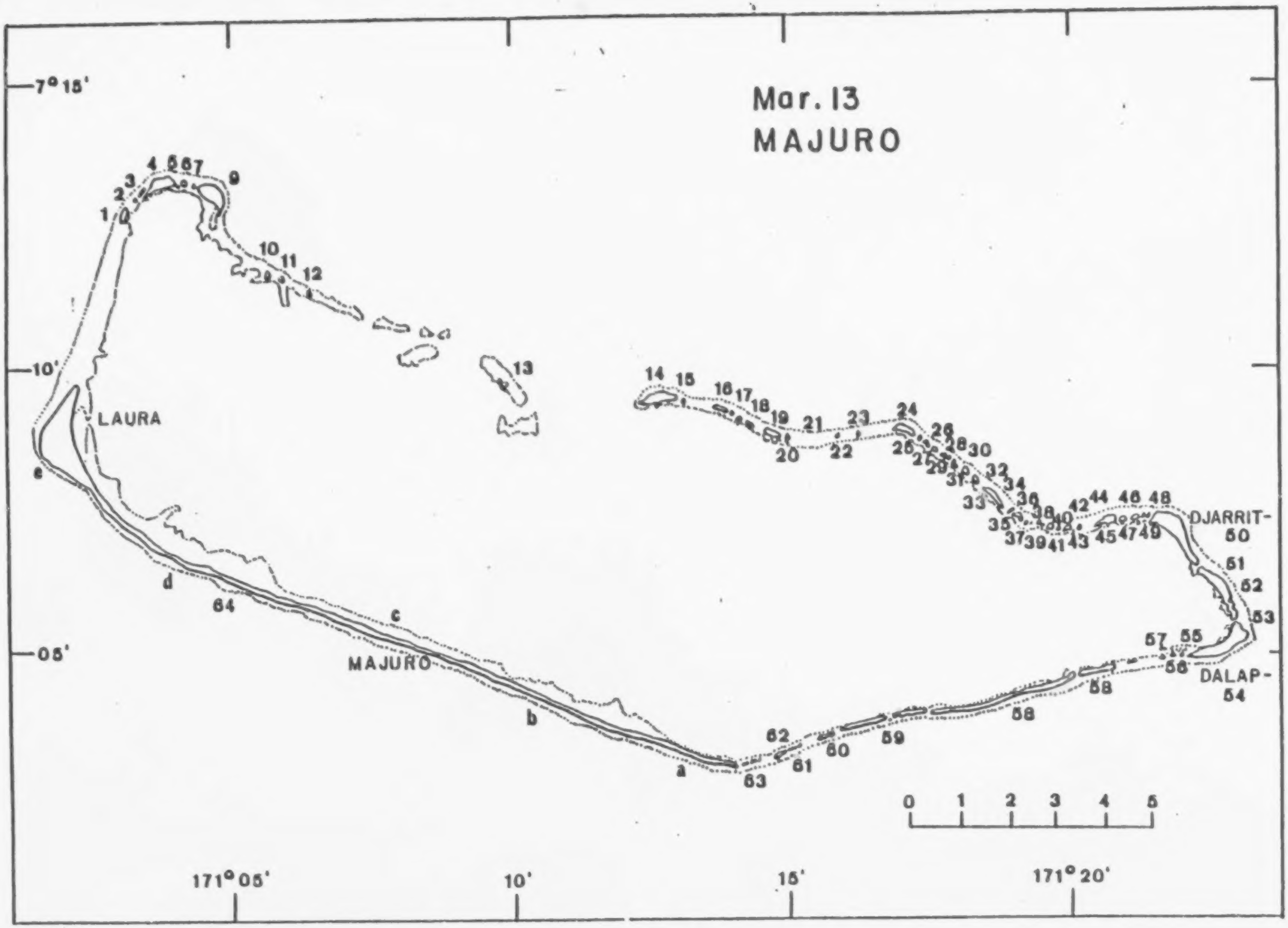
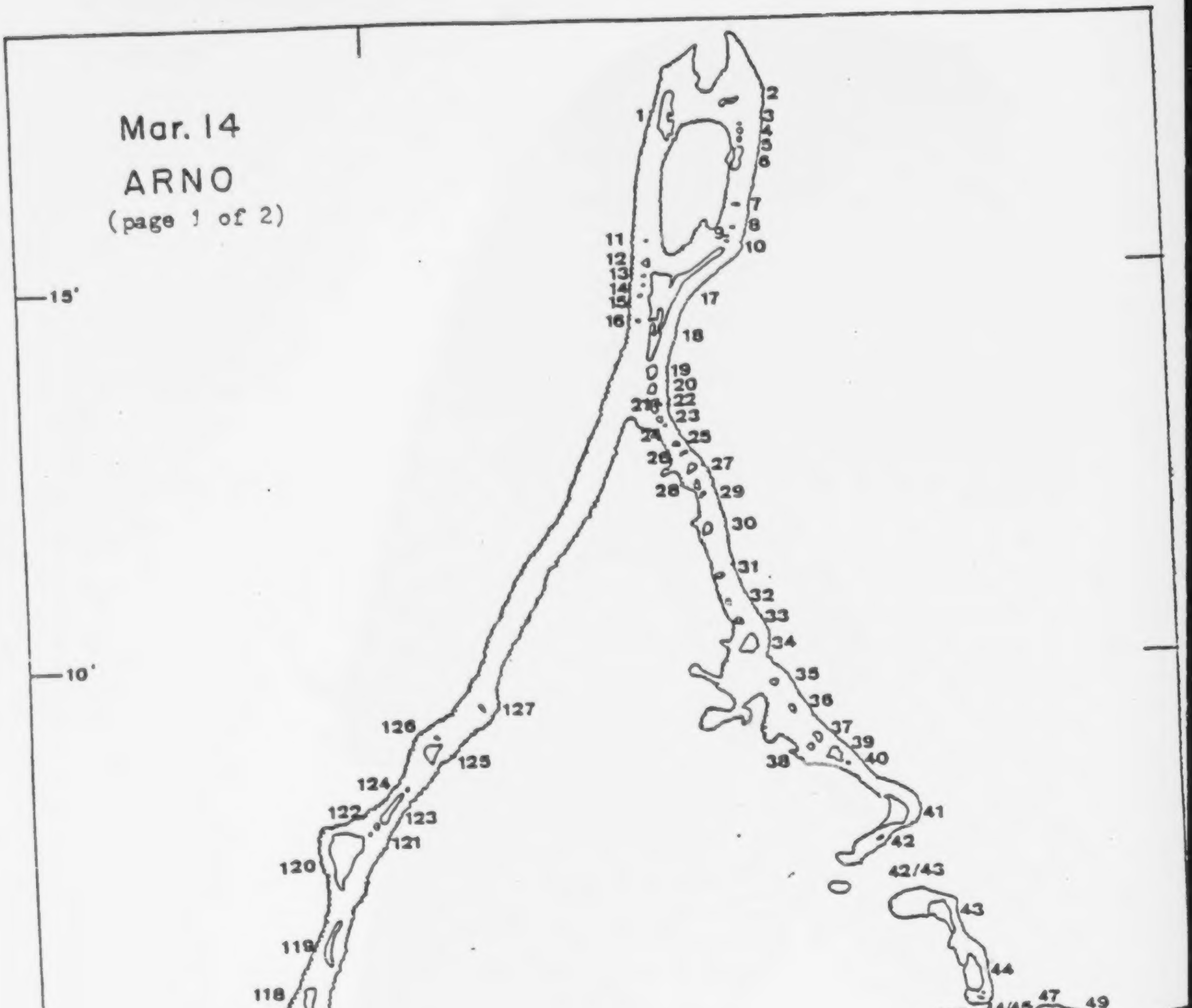

Mar. 13
MAJURO
7° 15'
10'
05'
171° 05'
10'
15'
171° 20'
0 1 2 3 4 5
LAURA
MAJURO
DJARRIT-50
DALAP-54
1 2 3 4 5 6 7 9
10 11 12
13
14 15 16 17 18 19 20 21 22 23 24
25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49
51 52 53 55 56 57 58 58
59 60 61 62 63 64
a b c d e



Mar. 14
ARNO
(page 1 of 2)

15'
10'
05'
7°00'
171° 35'
40'
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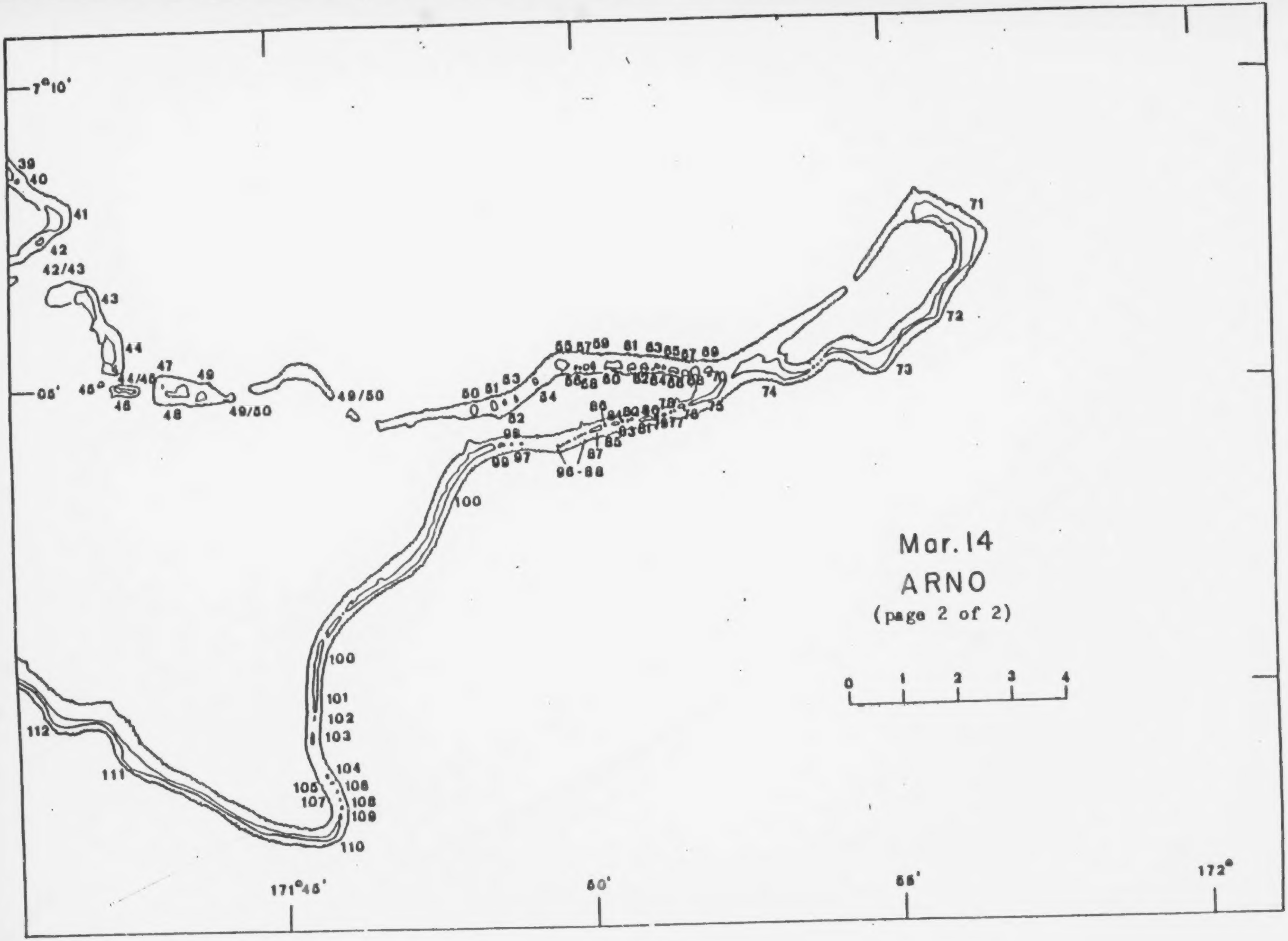

7°10'
05'
39
40
41
42
42/43
43
44
45
44/46
46
47
49
48
49/50
49/50
50
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53
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52
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57
59
61
63
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67
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86
84
82
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73
72
71
85
87
96-88
98
99
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100
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105
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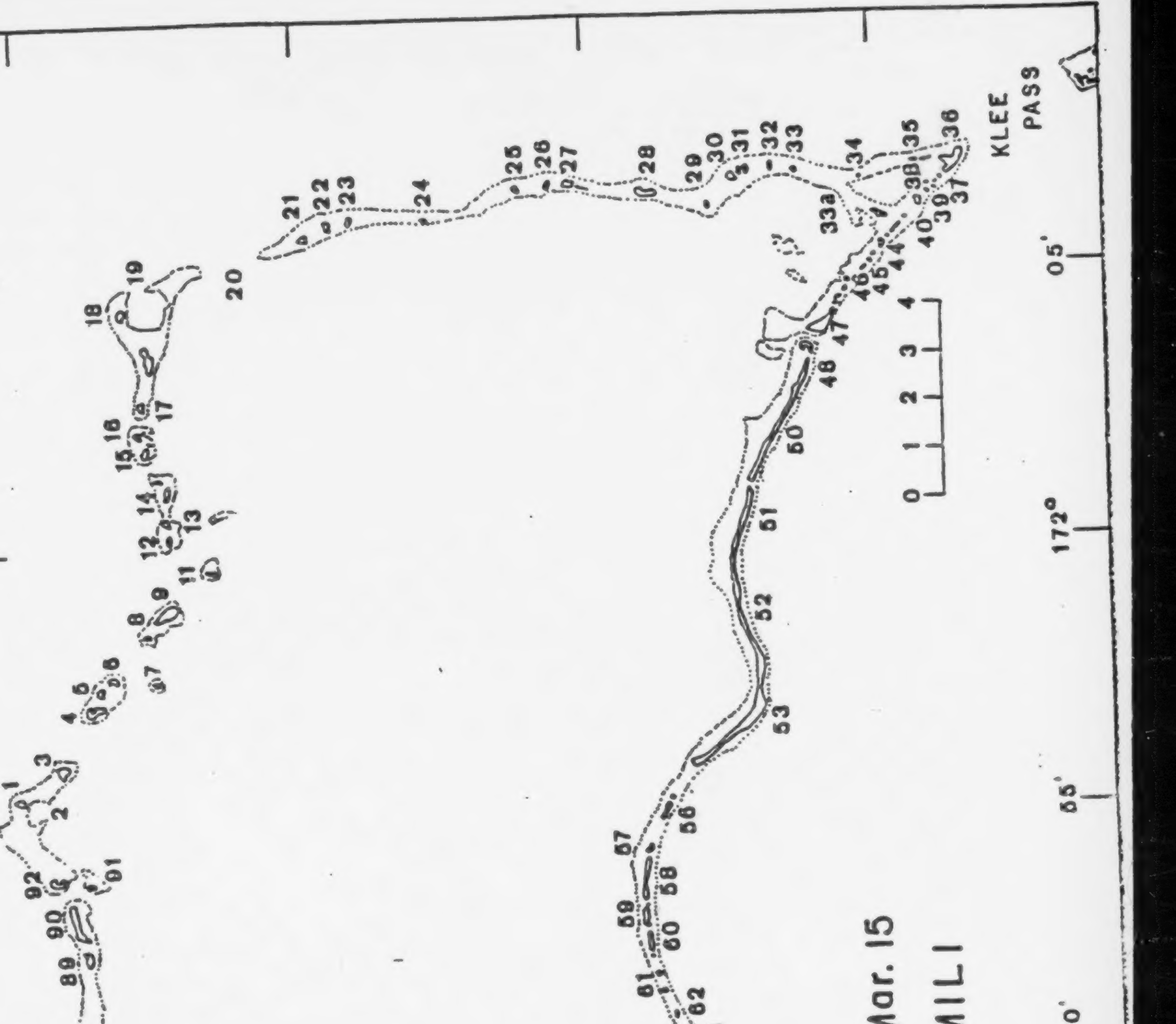
107
108
109
110
111
112
171°45'
50'
55'
172°
0
1
2
3
4

Mar. 14
ARNO
(page 2 of 2)


Mar. 15
MILI
Mar.15A
KLEE PASS
6°15'
10'
05'
6°00'
171°50'
55'
172°
05'
172°10'
5°55'
0
1
2
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33a
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81a
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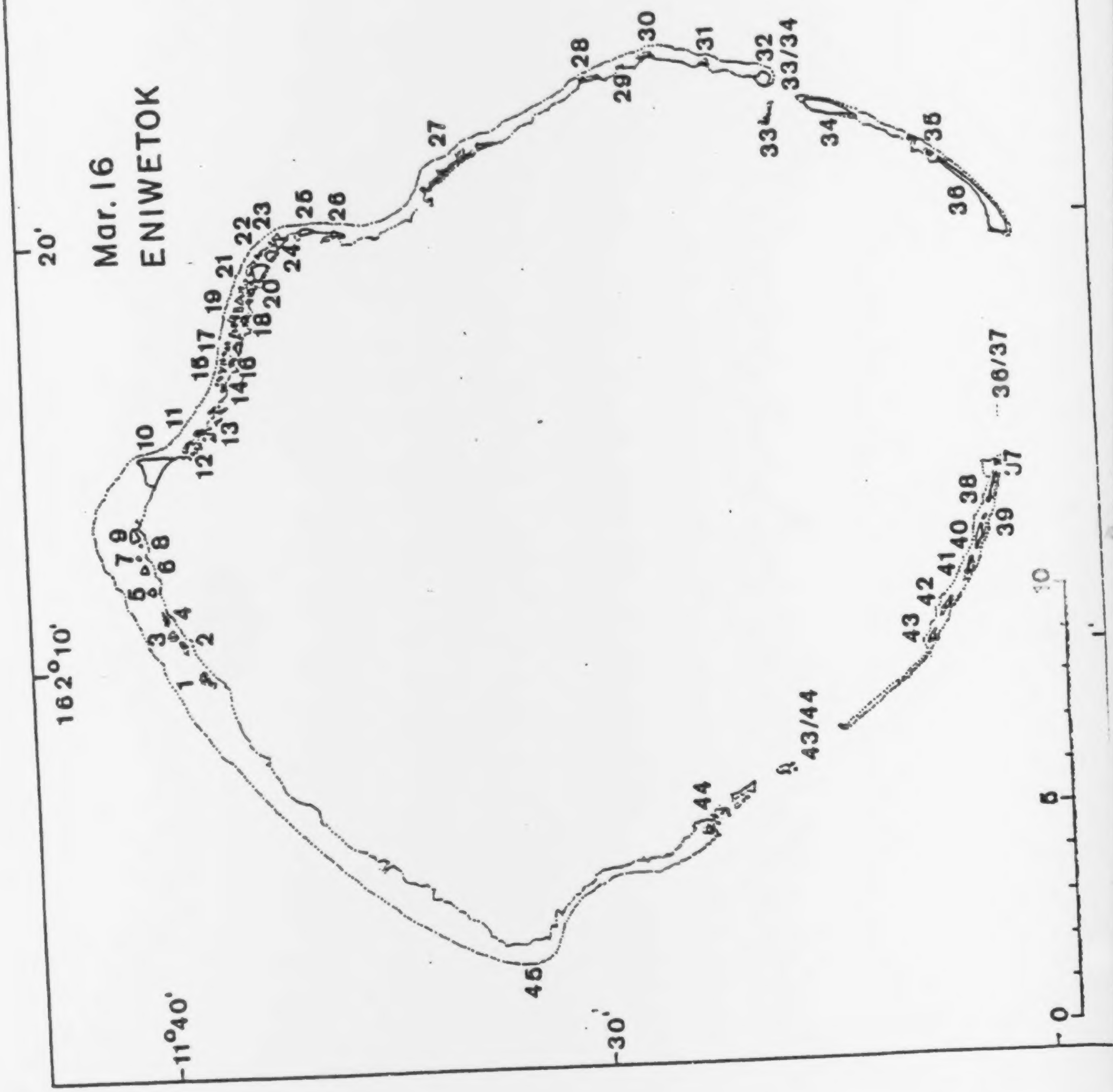
104


Mar. 16
ENIWETOK
162°10'
20'
11°40'
30'
0
5
10
1
2
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6
7
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31
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33/34
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36
36/37
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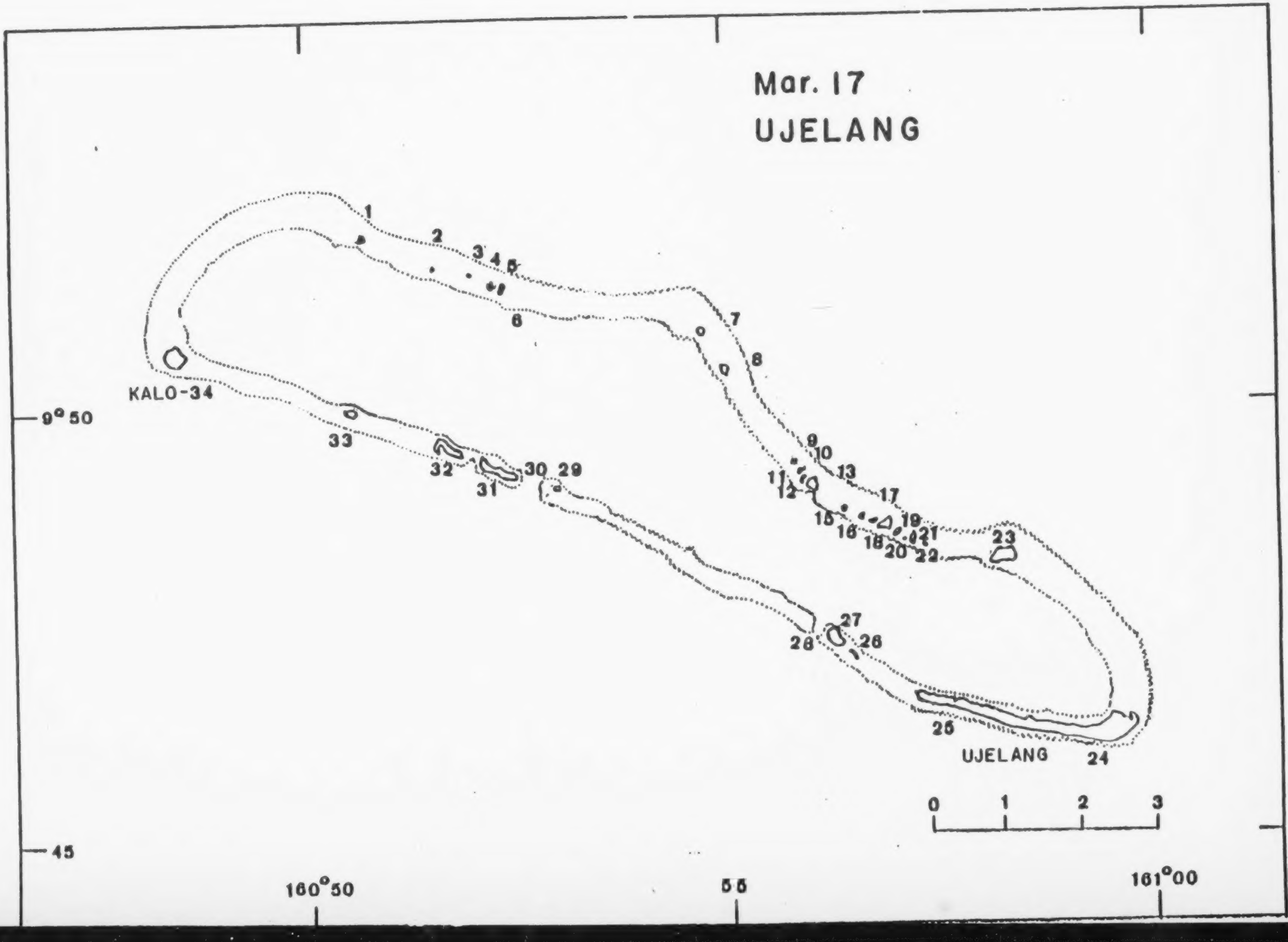
42
43
43/44
44
45


Mar. 17
UJELANG
1
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17
18
19
20
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23
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25
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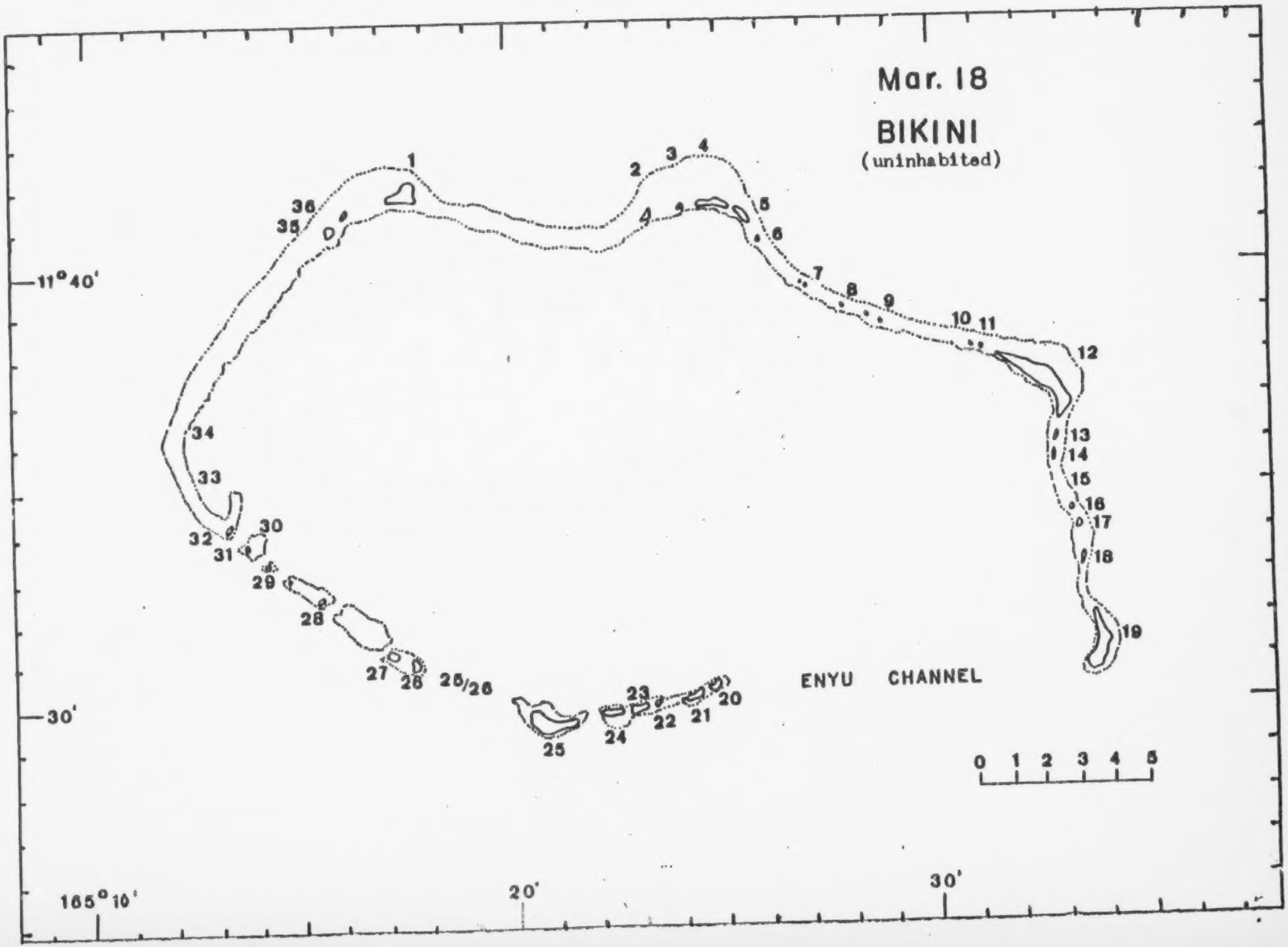
27
28
29
30
31
32
33
KALO-34
UJELANG
0
1
2
3
9°50
45
160°50
55
161°00


Mar. 18
BIKINI
(uninhabited)
1
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13
14
15
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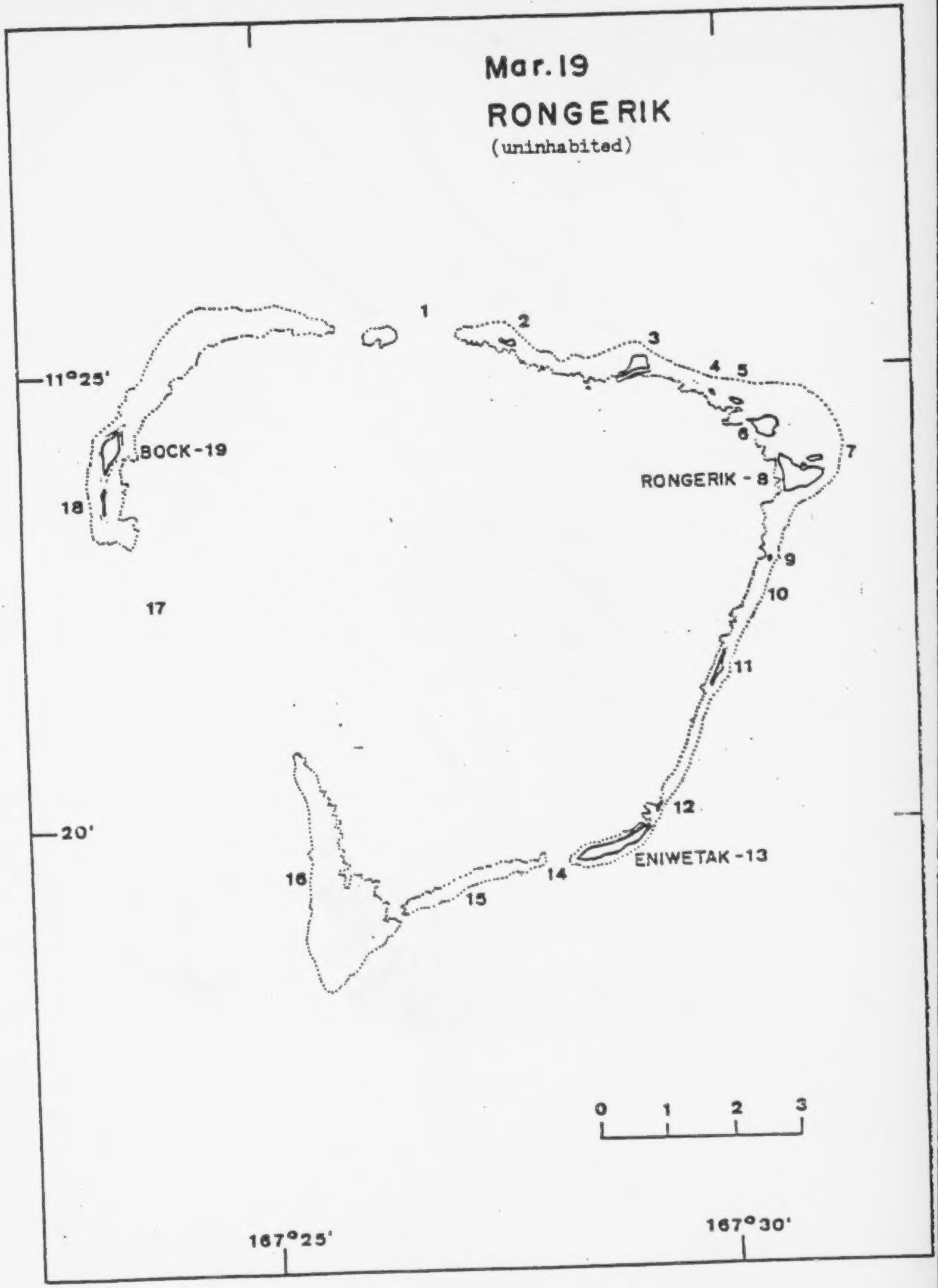
25
25/26
26
27
28
29
30
31
32
33
34
35
36
ENYU CHANNEL
0 1 2 3 4 5
11° 40'
30'
165° 10'
20'
30'

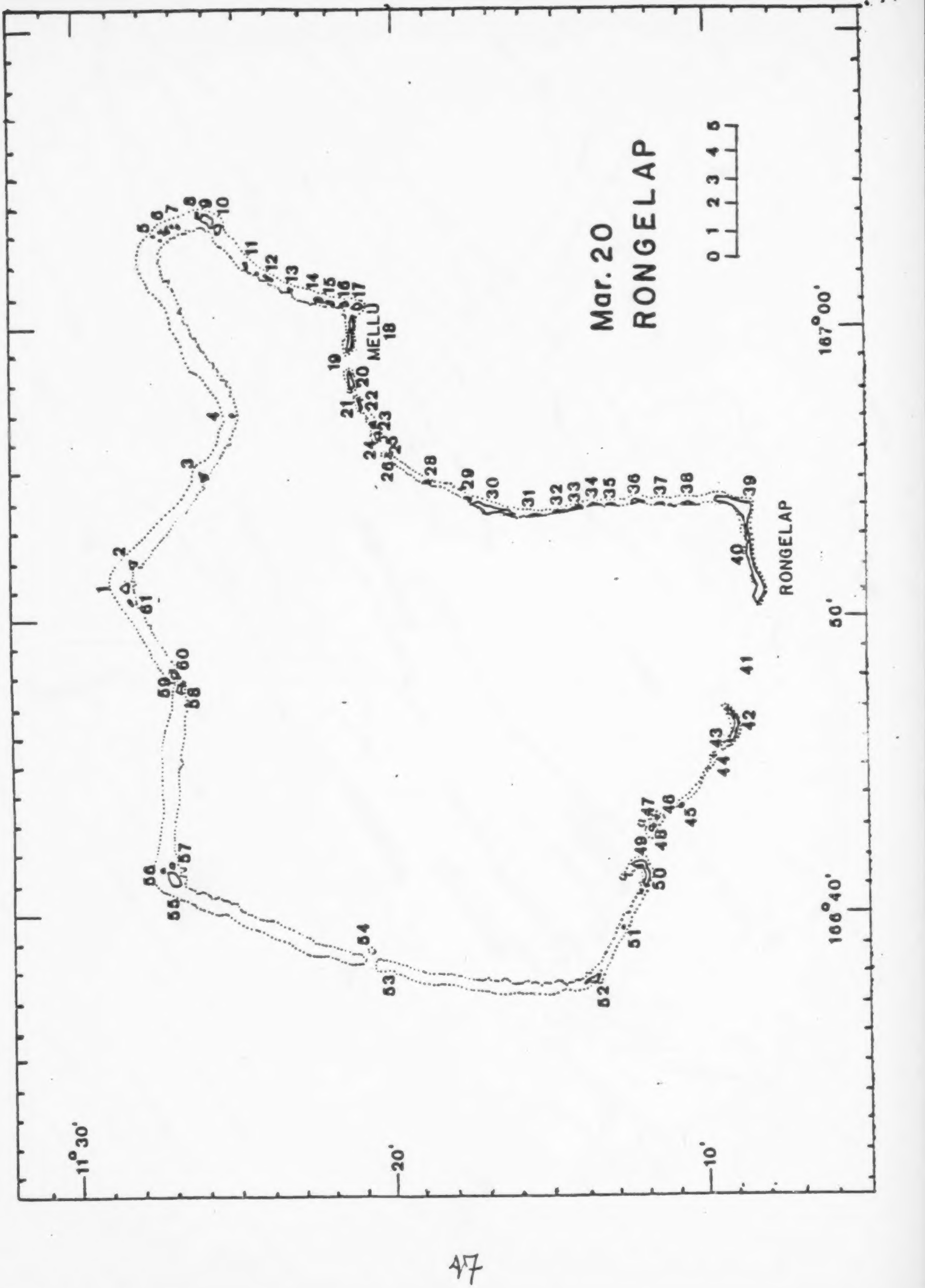


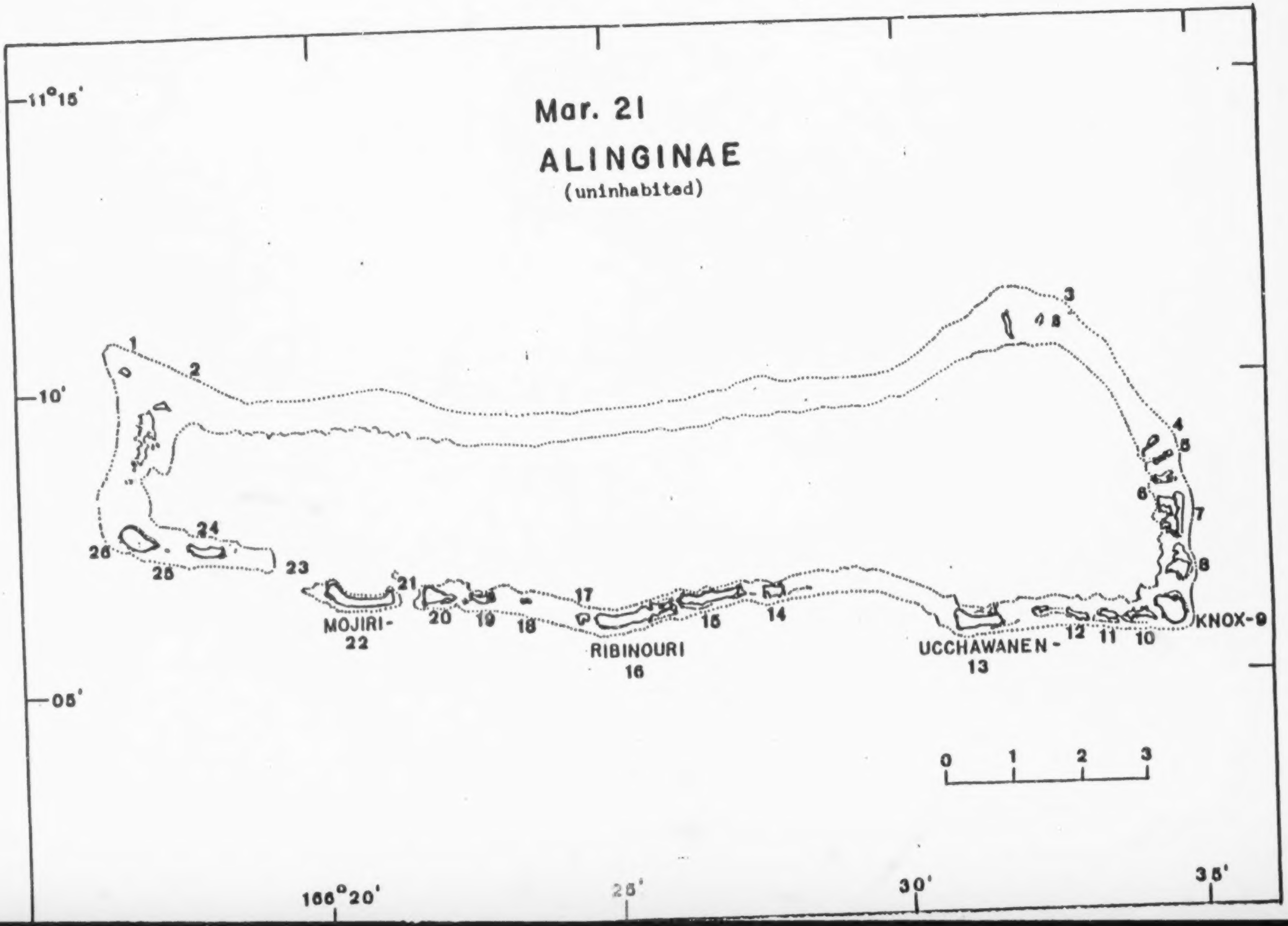
Mar. 19

RONGERIK

(uninhabited)

1
2
3
4
5
6
7
RONGERIK - 8
9
10
11
12
ENIWETAK - 13
14
15
16
17
18
BOCK - 19
11°25'
20'
167°25'
167°30'
0
1
2
3


Mar. 20
RONGELAP
0 1 2 3 4 5
MELLU
RONGELAP
167°00'
50'
166°40'
11°30'
20'
10'
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61


Mar. 21
ALINGINAE
(uninhabited)
-11°15'
-10'
-05'
166°20'
25'
30'
35'
1
2
3
4
5
6
7
8
KNOX-9
10
11
12
UCCHAWANEN-
13
14
15
RIBINOURI
16
17
18
19
20
21
MOJIRI-
22
23
24
25
26
0
1
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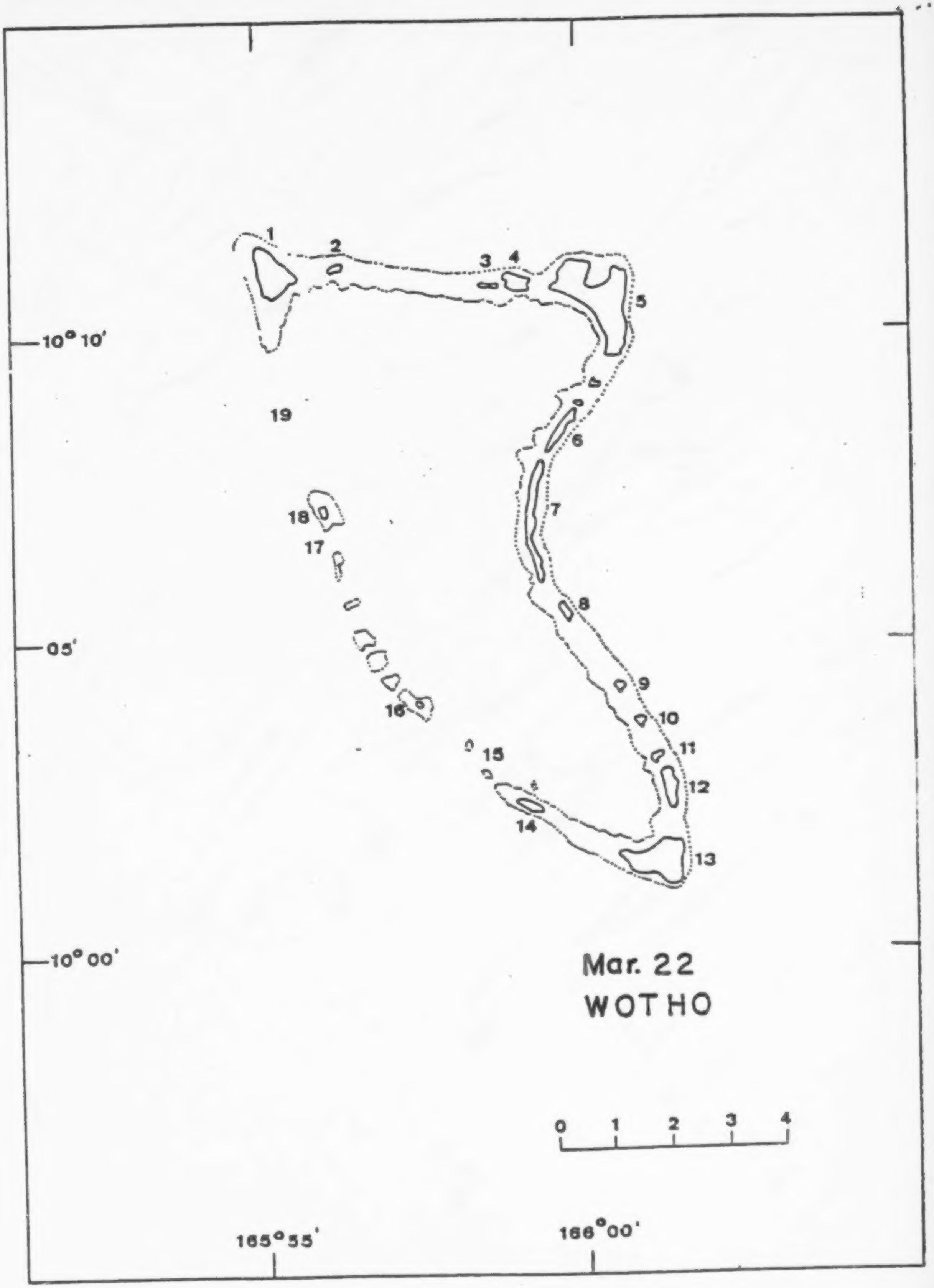
3


1
2
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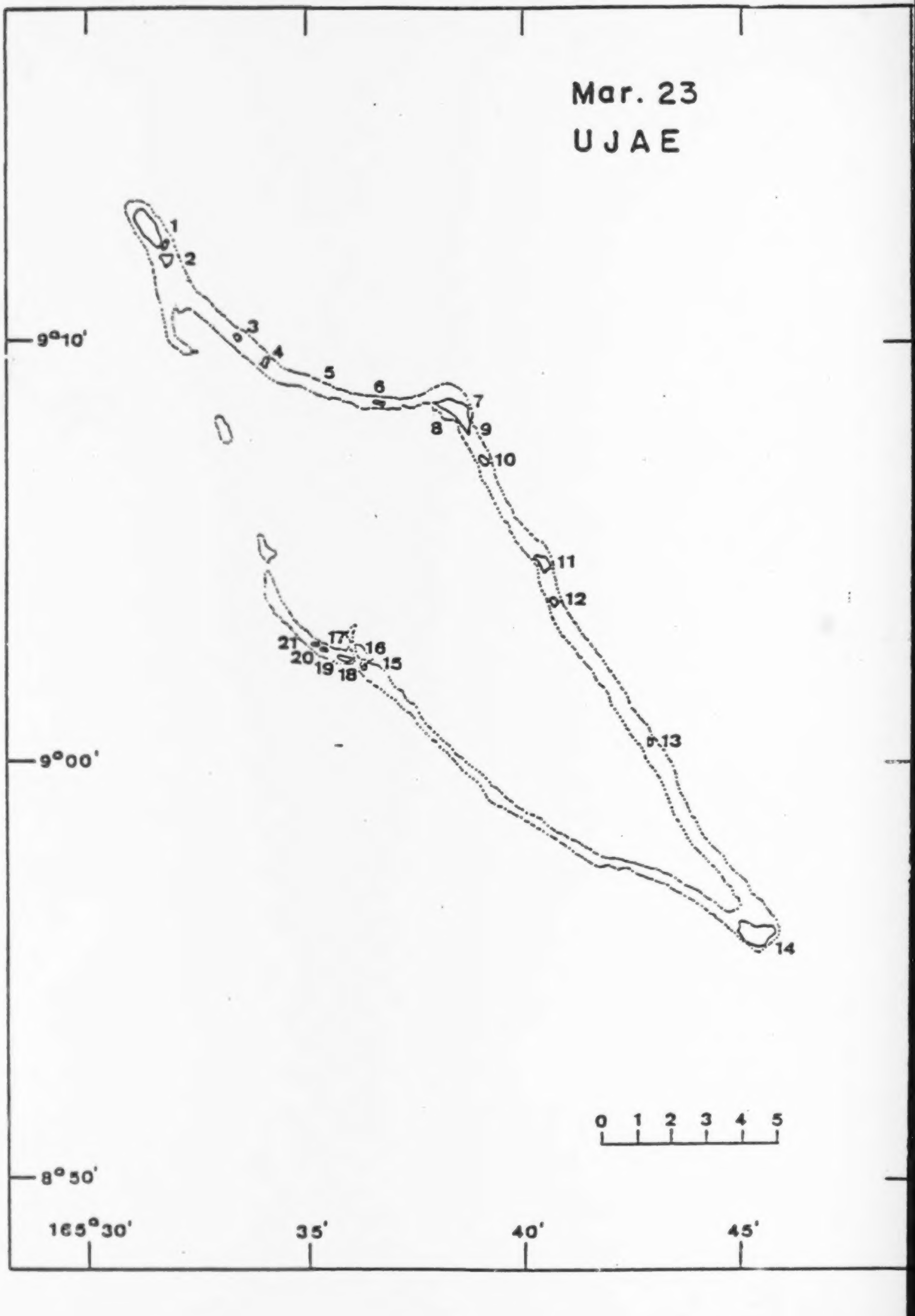
10
11
12
13
14
15
16
17
18
19
10° 10'
05'
10° 00'
165° 55'
166° 00'
Mar. 22
WOTHO
0
1
2
3
4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UJAE
1
2
3
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9
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12
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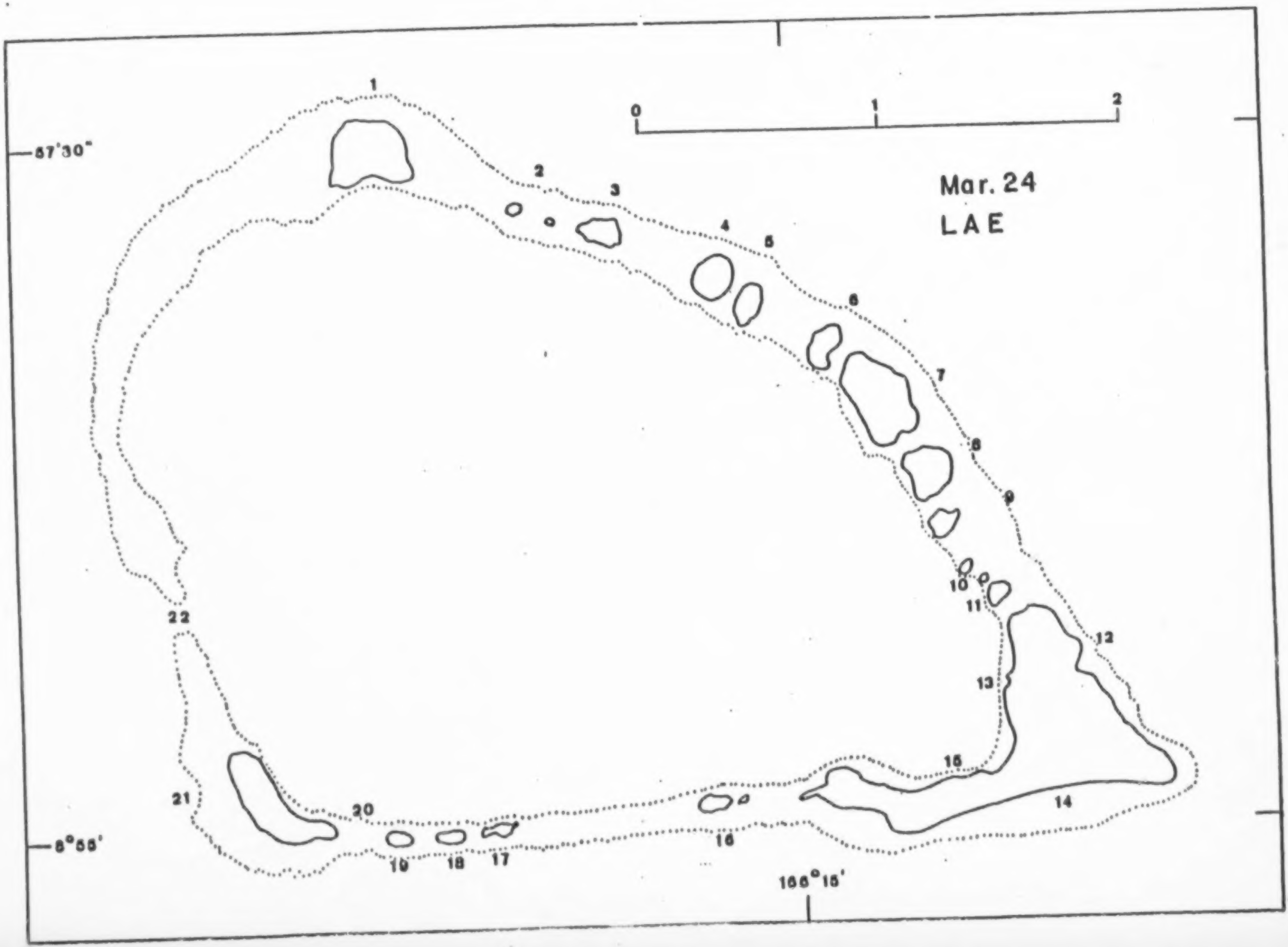
14
15
16
17
18
19
20
21
9°10'
9°00'
8°50'
165°30'
35'
40'
45'
0 1 2 3 4 5


Mar. 24
LAE
0
1
2
57'30"
8°55'
166°15'
1
2
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4
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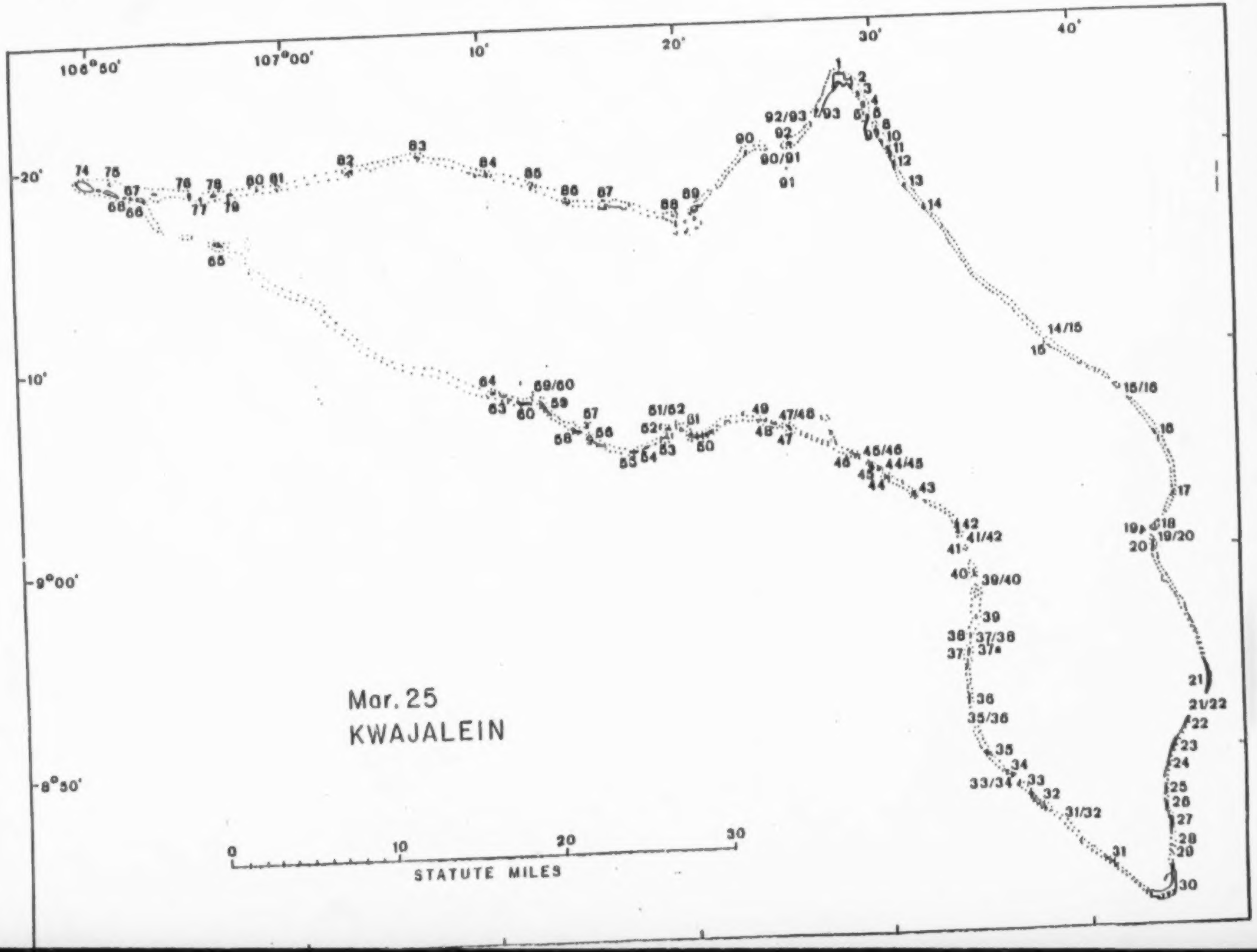
Mar. 25
KWAJALEIN

106°50'
107°00'
10'
20'
30'
40'
-20'
-10'
-9°00'
-8°50'
0
10
20
30
STATUTE MILES
1
2
3
4
5
6
8
10
11
12
13
14
14/15
15
15/16
16
17
18
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19/20
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21/22
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35/36
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37/38
37a
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86
87
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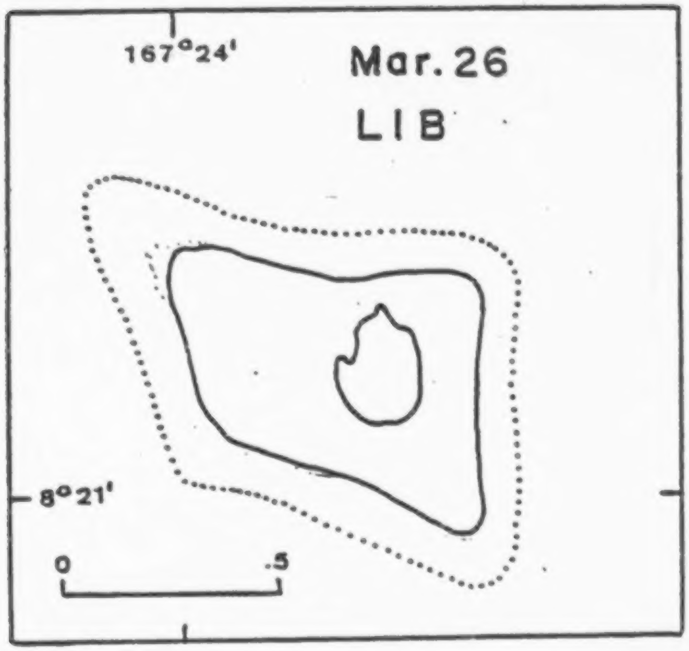
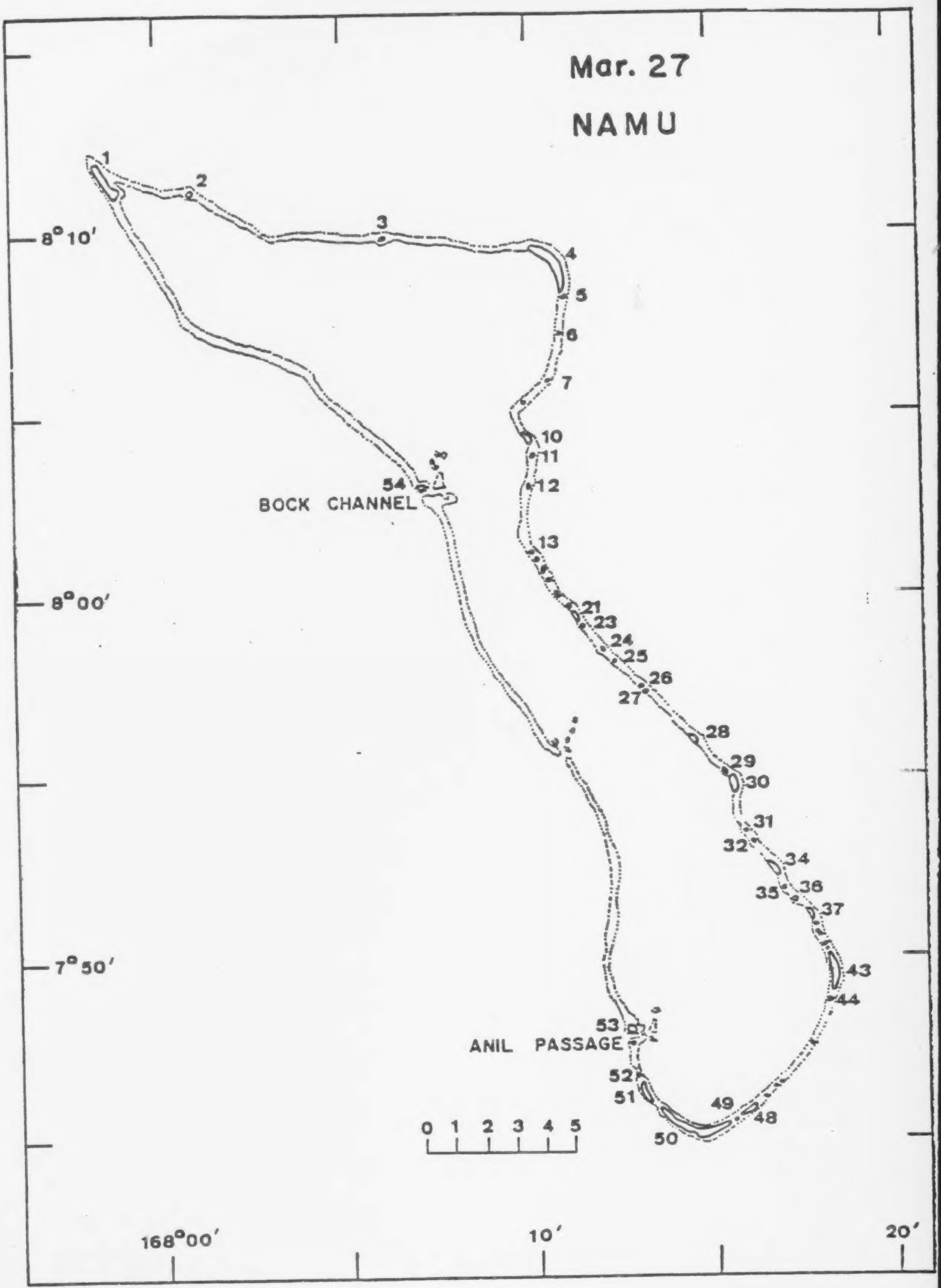
90
90/91
91
92
92/93
93


167°24'
Mar. 26
LIB
8°21'
0
.5


Mar. 27
NAMU
1
2
3
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6
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10
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12
13
21
23
24
25
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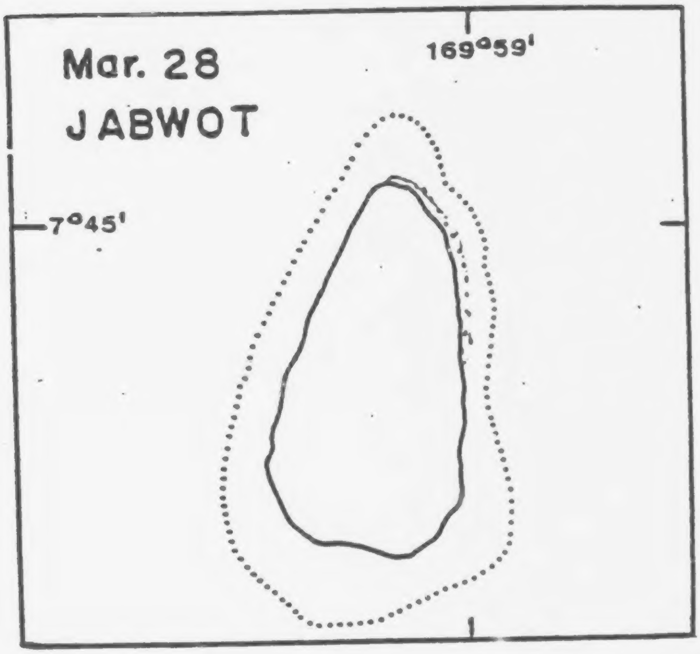
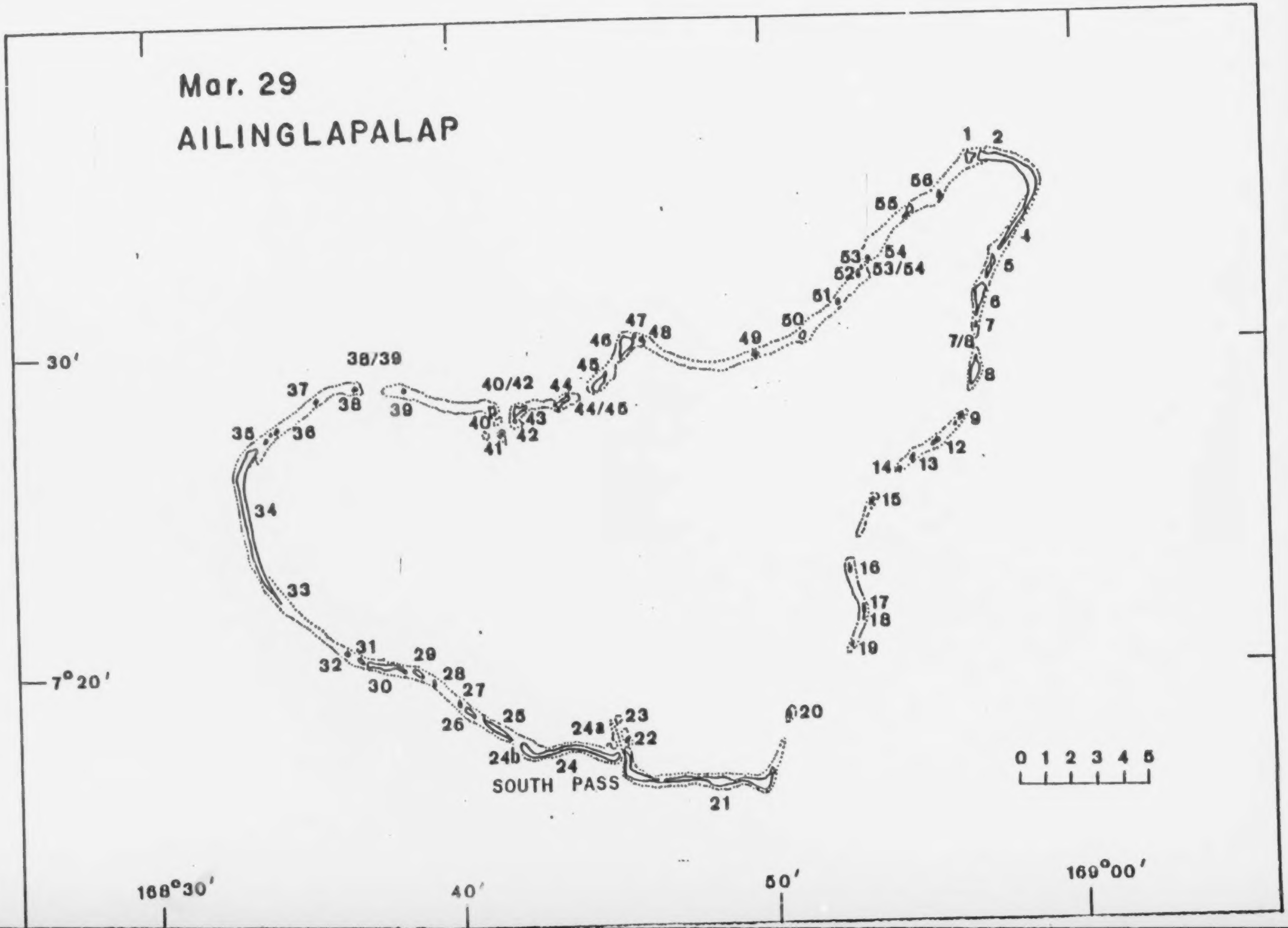
29
30
31
32
34
35
36
37
43
44
48
49
50
51
52
53
54
BOCK CHANNEL
ANIL PASSAGE
0 1 2 3 4 5
8°10′
8°00′
7°50′
168°00′
10′
20′


Mar. 28
JABWOT
169°59'
7°45'


Mar. 29

AILINGLAPALAP

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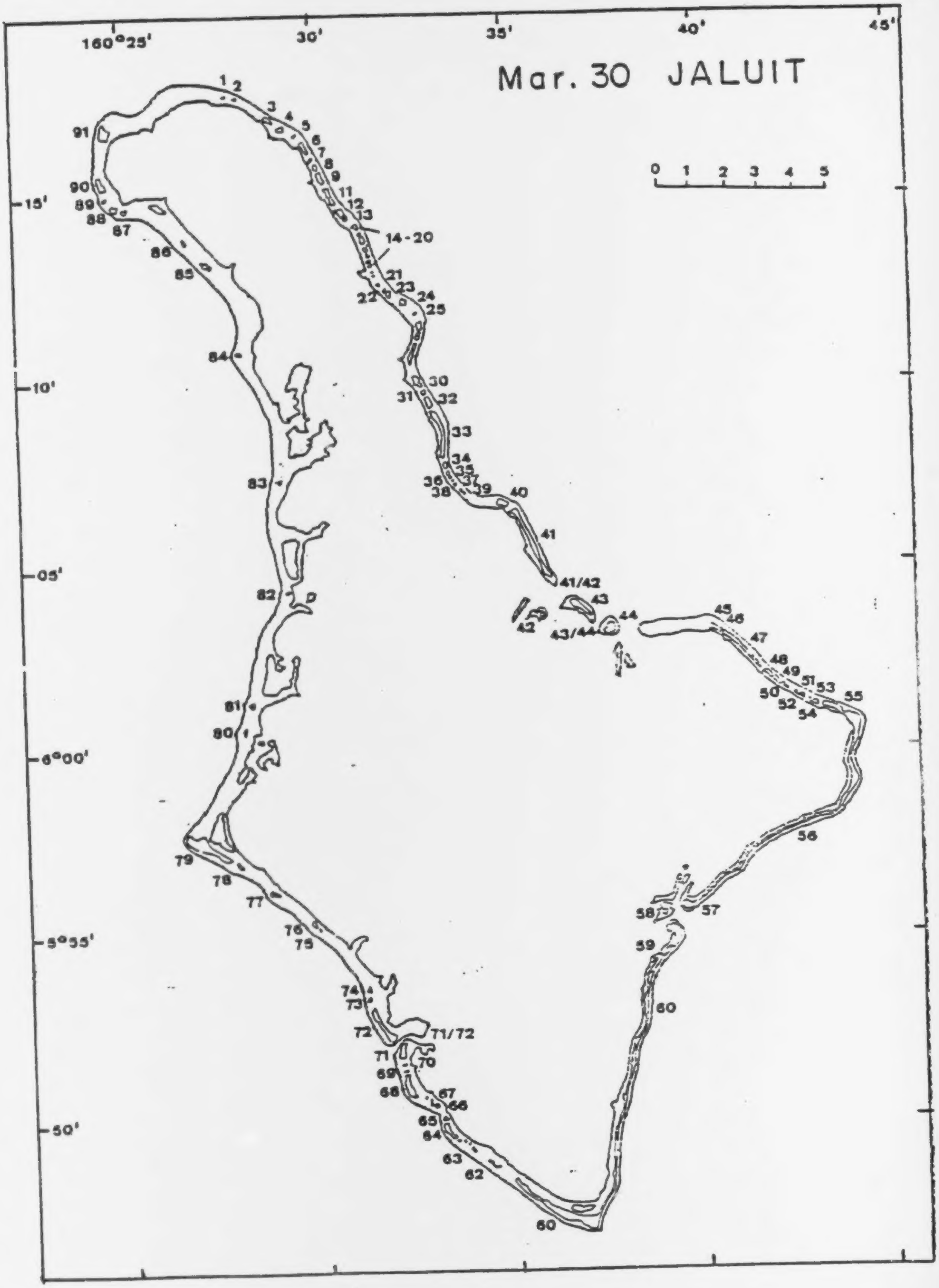
24a
24
24b
SOUTH PASS
25
26
27
28
29
30
31
32
33
34
35
36
37
38
38/39
39
40/42
40
41
42
43
44
44/45
45
46
47
48
49
50
51
52
53
54
53/54
55
56
0 1 2 3 4 5
30′
7°20′
168°30′
40′
50′
169°00′


Mar. 30 JALUIT
160°25'
30'
35'
40'
45'
15'
10'
05'
6°00'
5°55'
50'
0 1 2 3 4 5
1 2
3 4 5 6 7 8 9
11 12 13
14-20
21 22 23 24 25
30 31 32 33
34 35 36 37 38 39 40
41
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45 46 47 48 49 50 51 52 53 54 55
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62 63 64 65 66 67 68 69 70 71
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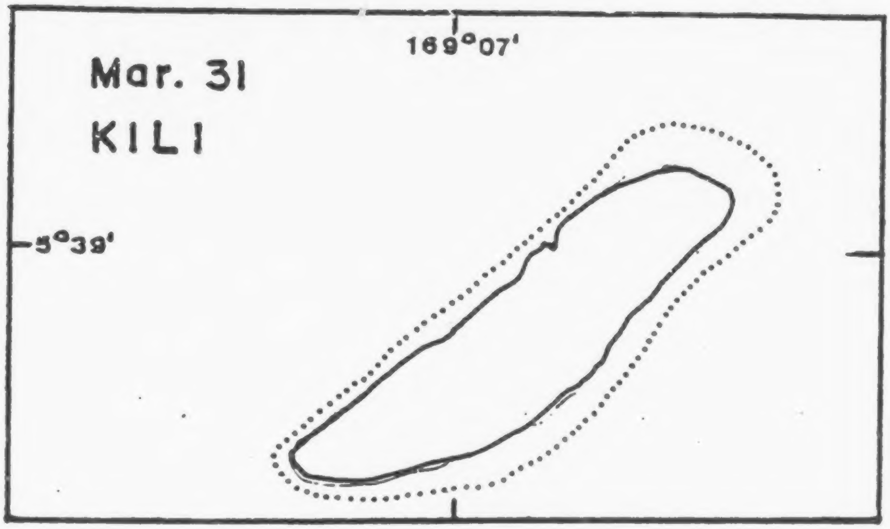
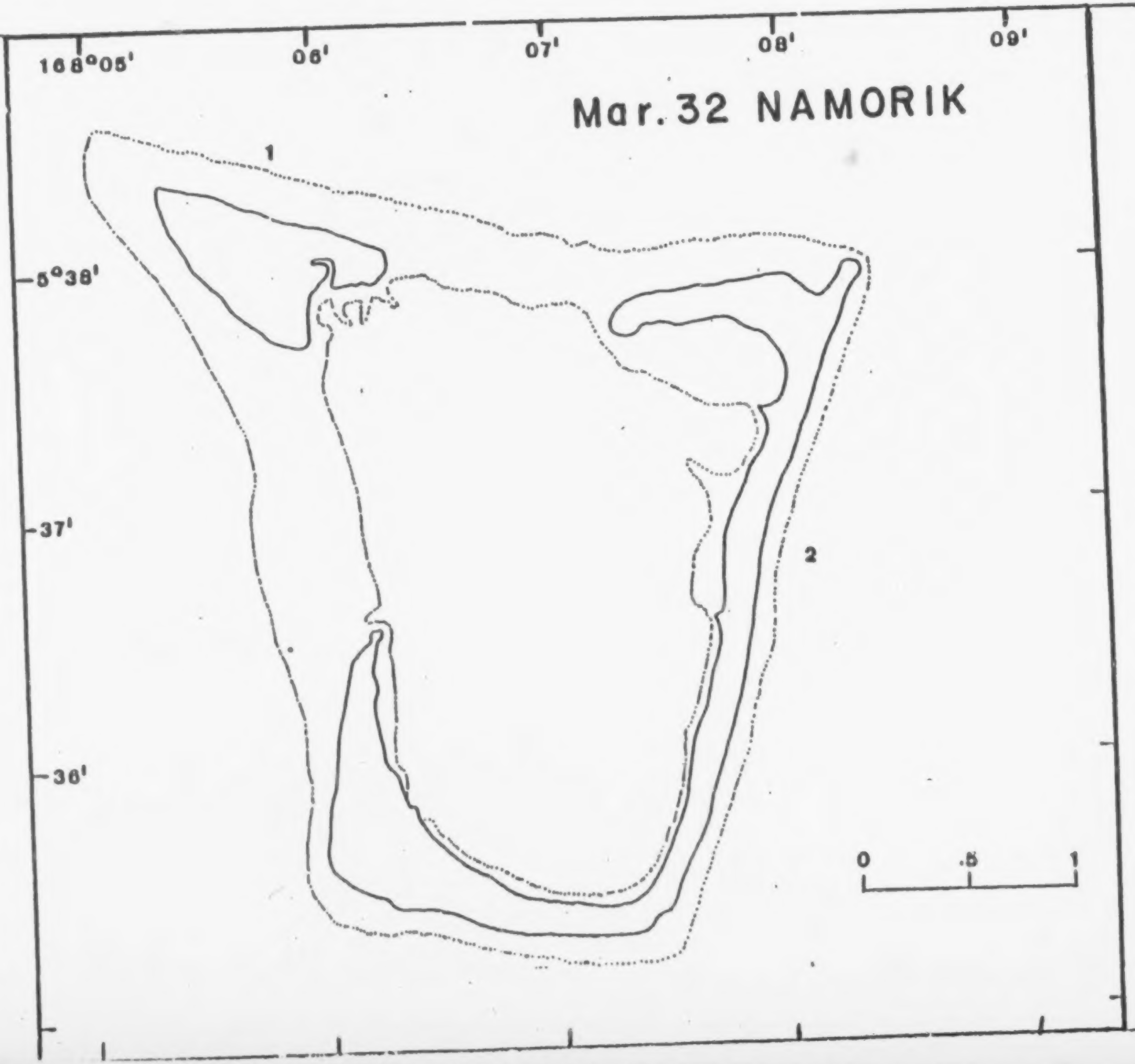
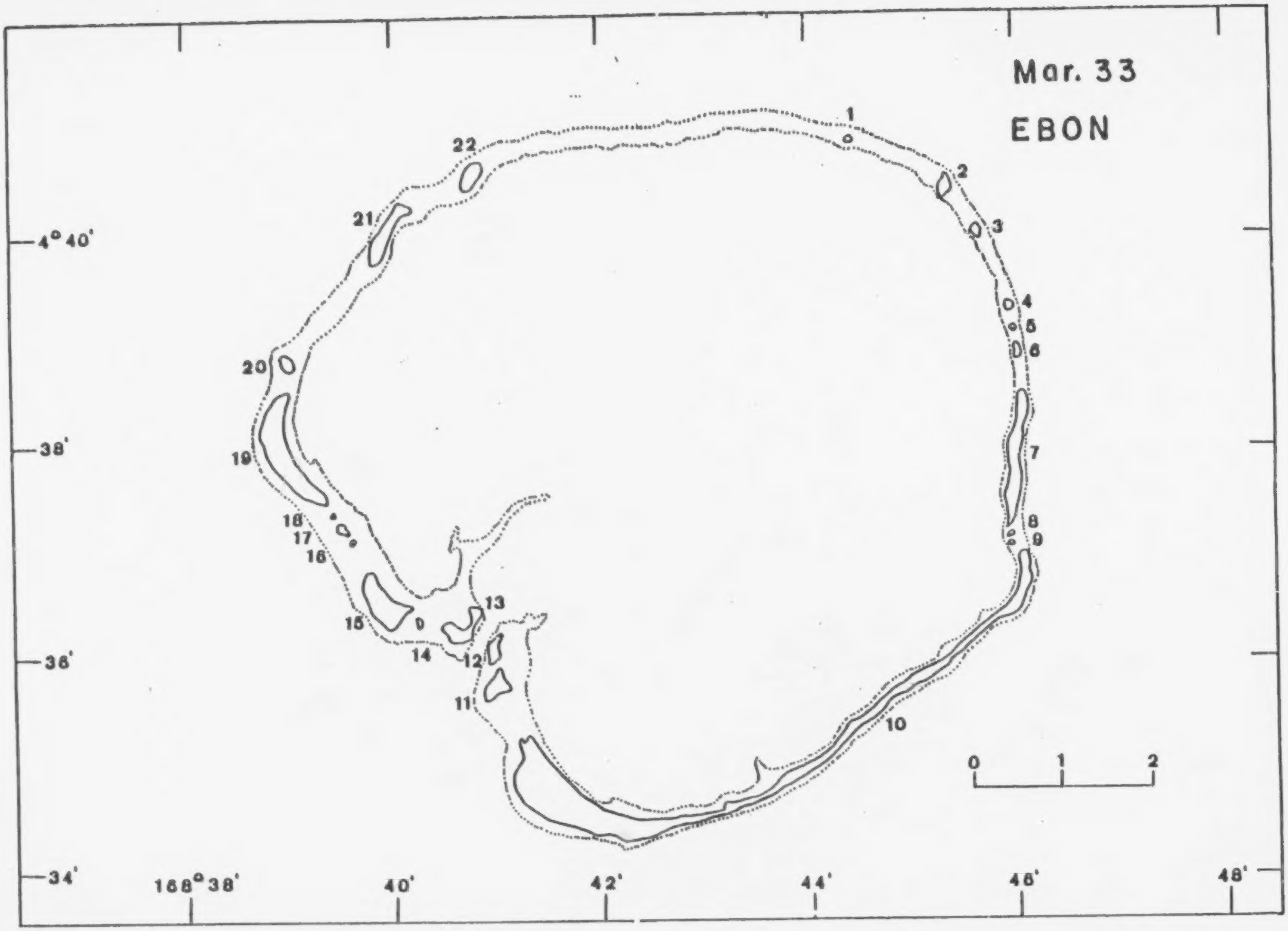
80 81 82 83 84 85 86 87 88 89 90 91


169°07'
Mar. 31
KILI
5°39'



Mar. 32 NAMORIK

168°05'
06'
07'
08'
09'
5°38'
37'
36'
1
2
0
.5
1


Mar. 33
EBON
1
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4
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12
13
14
15
16
17
18
19
20
21
22
0
1
2
4° 40'
38'
36'
34'
168° 38'
40'
42'
44'
46'
48'

Background Paper No. 2

FORESTRY AND AGROFORESTRY TECHNOLOGIES: DEVELOPMENT POTENTIALS IN THE U.S.-AFFILIATED PACIFIC ISLANDS

by

Craig C. Halbower

1986

Prepared for

U.S. Congress, Office of Technology Assessment,
Integrated Renewable Resource Management for U.S. Insular Areas,
Washington D.C.: U.S. Government Printing Office, 1987.

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ABSTRACT

INTRODUCTION

AGROFORESTRY
  Background
  The Micronesian Connection
  Agroforestry Crops
  Commercial Prospects
  Agroforestry Research and Development Potential

FOREST RESOURCE ASSESSMENTS
  Background
  Timber
  Energy
  Fibre
  Traditional Specialty Products
  Rare and Endangered Speceis
  Outdoor Recreation

SUMMARY OF CONSTRAINTS AND MANAGEMENT OPPORTUNITIES
  Socio-economic Issues
  Technology Implications
  Priorities for Applying Research and Development
  Effective Institutional Actions and Implications

LITERATURE CITED

Table I. FSM Food Production 1980

Table II. The American Territiories of the Pacific: with population, land area, electricity demands, and preliminary assessment of biomass (wood) potential

ABSTRACT

The status of the tropical forests in the U.S. affiliated territories of Micronesia are in a somewhat peculiar position compared to other tropical forests of the world. User demands are not as intense owing to the facts that the majority of residual stands offer few merchantable opportunities; traditional shifting farming systems, where still practiced, require little land; and population levels and the socio-economic conditions prevalent on the high islands creates only the slightest pressures to exploit these resources. Hence, these forests do not face a serious deterioration problem.

Although forest vegetation originally covered most of the islands, few undisturbed vegetation remains. The brunt of the degradation occured in ancient times, when population levels were five times that of today, and during World War II. Presently, most of the detrimental impacts come from the constant burning of savanna and grasslands, and from construction projects requiring extensive land clearing (especially in watershed areas). The closed forests are in a state of abeyance. In the open forests one sees the languid use of traditional or backyard agriculture.

The local government's forestry and agro-forestry development efforts are somewhat static - seemingly administered by benign neglect. There are, however, opportunities in Micronesia to enhance traditional farming practices and develop forestry potentials. Many technologies are readily transferable to this region. Their applications are hampered by institutional and socio-economic factors than by environmental considerations. Deficiencies of education and training, local administrative capabilities and funding, make integrated agroforestry programs difficult to manage. Unfortunately, development to date has been haphazard under the direction of various temporary expatriate specialists.

The academic concept of self-sufficient agroforestry is relatively new. It is generally associated as a subdivision of forestry, although the agricultural crops are of paramount importance to the farmer. A properly managed program should assimilate the two disciplines. The establishment of large-scale, integrated upland agroforest farms will likely fall under the direction of forestry personnel. Effective land use strategies must be as flexible and diverse as the environments targeted.

Implementing institutions must remain cognizant of the fact that these islands have been the subject of a myriad of studies, plans and tests, of relatively little consequence. Many islanders have become rightly hesitant to support new "research". Any land use project utilizing private land must be workable, and must not be construed as a "test" (although useful data may be obtained) as the word has come to have negative connotations.

The biggest deterent to agroforestry programs are the regional socio-economic issues. These islands are dependent to varying degreees on outside subsidies. Many island economies are characterized by inflated wage structures and the vast importation of consumable goods. The high status associated with these imported commercial products contributes to the decline of traditional farming practices and further reduces self-sufficiency. There is a growing awareness of the intrinsic values of tradional agroforest farming, but proponents find themselves in contention with advocates of non-traditional forms of agriculture (e.g., extensive mechanization, mono-cropping, use of imported fertilizers, etc.). Little production has been realized by non-traditional forms of agriculture, but it is still emphasized by international institutions and local governing bodies (no doubt influenced by the former). For most island environments this policy should be abated.

INTRODUCTION

This paper assesses the applicability and potential of forestry and agroforestry technologies in the U.S. affiliated islands of Micronesia (Guam; the Commonwealth of the Northern Marianas; the Republic of Belau; and the Federated States of Micronesia including Yap, Truk, Pohnpei and Kosrae). Assessments and recommendations must take into consideration the disparate cultures, demographics, socio-economic factors and environmental conditions of this vast region. Since literature is readily available on the forest influences of these islands (soils, geomorphology, climate and vegetation) they will not be extensively covered in this paper.

Traditional agriculture is the primary land use of the forest. It is discussed first. The evolution of farming practices in Southeast Asia and Oceania are presented as background. Present agroforestry in Micronesia is discussed centering on the Yapese farming practices. The Yapese are more closely tied to the land than most other Micronesian cultures, and the author is most familiar with the ethnobotanics of this culture. The agroforestry crops, commercial prospects and research needs for this region are then submitted.

The forest resources are assessed for other uses. A summary of forestry and agroforestry constraints and management opportunities follow. Included in this section are the main socio-economic issues that must be addressed, the implications of successful technology transfer, the priorities for applying research and development, and the effective institutional actions that are required for development.

AGROFORESTRY

BACKGROUND

Long before the occupation by any foreign power, Micronesians were practicing an efficient subsistence farming system we now call agroforestry. The basic principle is for a small amount of land to provide an array of agriculture and forest products, without being unduly labor intensive, and basically maintaining soil fertility. Ideally, agroforestry can maintain an equilibrium between man and his environment (Budowski, 1982; King, 1979). While some practices are the main cause of destruction of the world's tropical forests (Maydell, 1978).

Agroforestry is generally known as a shifting farming system. Conklin (1957 & 1963) and Pelzer (1945 & 1959) noted five general characteristics in defining this practice:

1) Fields rather than crops are rotated.
2) Croppping is brief (1-3 years), followed by a long fallow.
3) Land is cleared by slash and burn.
4) Usually only human labor is used.
5) Settlements are transient.

There are three general types of agroforestry, defined by cultivation and forest fallow sequences, spatial relationships, environmental impacts and the potential for sustaining productivity. The first is traditional cyclical shifting agroforestry. Forests are cleared and food crops are continuously cultivated from 1-4 years, then abandoned for 8-20 years, then recultivated (Russell, 1968). Food crops and forest cover grow sequentially and are never intercroppped on the same site. However, this practice has been successfully employed for centuries throughout the upland tropics.

The key to the relative success of this particular farming system hinges on a short cropping period and a long fallow of at least 10 years. During cultivation the loss of protective forest cover exposes fertile topsoil to erosive forces. The percolation of water-soluble nutrients and the removal of nutrients stored in the crops during harvests also depletes soil fertility. It has been shown that the longer the cropping phase, the more severe the soil damage (Kunstadter, 1978) and the less likely the forest is to recover without additional applications of nutrients.

Forest cover is extremely critical in rehabilitating the cropped area during the fallow period (Ahn, 1978). Trees with deep penetrating roots can retrieve nutrients leached down in the soil. These nutrients are stored in the leaves, fruit and branches that eventually accumulate as forest litter, and become available for other flora. This litter, along with the forest canopy, reduces runoff and erosion and helps retain soil moisture. The quick decomposition of forest litter creates the tropical paradox of lush vegetation on relatively infertile soils.

Figures show (Sabharsi, 1978) that tree growth (as a function of available biomass) is maximum in a stand's first four years. Growth lags until the seventh year, then accelerates again until the tenth year. Crop fallow periods of under 10 years preclude this second spurt; sites become progressively denuded and subsequent productivity is diminished. Regrettably, many cultivators have deviated from the optimum continuum by steadily increasing the croppping period and decreasing the length of fallow. Coupled with the usual progression of using the land for grazing, this trend has lead to the massive destruction of tropical forests worldwide (Maydell, 1978; and Myers, 1980).

A second method of agroforestry, called "Taungya", was formed in Burma a century ago in response to problems caused by shifting cultivators (primarily trying to remedy the transcient aspects of the settlements). It entailed the establishment of both agricultural and forest crops. This practice mitigated the detrimental effects of cultivation and expedited the succession to forest. But, ultimately, it still necessitated the transfer of farmers from one locale to another, though not as soon as the cyclical approach. Since a timber plantation is the ultimate conclusion of this system, as the canopy closes it precludes further cultivation and permanent communities. In adddition, the introduced trees were slow growing luxury timbers, requiring non-productive field crop rotations of 40-70 years (Boonkind, 1978).

A more permanent solution calls for an intensively managed system of simultaneous and continuous tree and foodstuff farming (ICRAF, 1983). This third agroforestry approach is based on intercropping forest cover, usually retained in blocks or rows, or dispersed randomly throughout the plantation. Productivity can be increased by interplanting multi-storied crops of short and long durations. Nutrient uptake is more balanced throughout the soil profile due to the different depths of root penetration of field and tree crops. Intercropping preserves diversity, acts as insurance if some crops fail, and spreads cash income throughout the year as crops are harvested in different seasons.

Unlike traditional shifting agroforestry, this system treats the timber species as marketable crops and rotates them with agriculture crops. Agriculture crops benefit environmentally from their association with tree cover (Budoski, 1982; and ICRAF, 1983), and internediate and long-term cash income is derived from the timber or edible produce these trees provide. In the Philippines and parts of Southeast Asia where this system is practiced, the interplanted trees are usually fast growing legumes harvested for pulp (Veracion, 1979) thus, the canopy never fully closes.

THE MICRONESIAN CONNECTION

Agricultural productivity in Micronesia peaked during the Japanese occupancy. On Saipan, Tinian, Rota and Pohnpei 30,000 acres of sugar cane were established. Approximately 3,500 acres of cassava were planted on Pohnpei, Belau and the Marianas; the starch was used in adhesives and textile materials. Copra production peaked at 17,000 tons per year. Other crops produced by or for the Japanese included pineapple, fibres, vegetables and rice.

This development was administered, subsidized and predominately manned by the Japanese (later, however, with the advent of war, natives became the primary labourers). The Micronesians benefited little from this association. With the exception of copra, these agro-industries were never rejuvenated after the war due to the lack of local know-how and a ready export market.

The monocultural farming system of the Japanese, coupled with the ravages of war, stifled a unique brand of Micronesian agroforestry. Unfortunately, western influences did not entirely remedy this situation. Though declining in practice in most of Micronesia, agroforestry is still an integral part of the more traditional Yapese lifestyle. Yap farming systems contain attributes of shifting, Taungya and integrated agroforestry practices.

The lowlands under forest cover contain the most fertile soils. Consequently, most of the villlages and gardens are located in these areas. The best examples of Yapese integrated agroforestry are found along village trails. These stone-covered trails are often a maze through local family "supermarkets". Giant swamp taro, Cyrtosperma chamissonis, is the predominate cultivated species and the mainstay of the Yapese diet. Permanent, shallow, poorly drained trao pits are excavated; the shifting cultivation of this taro is not practiced. Undecomposed plant material is continuously added to taro patches to maintain soil tilth.

Small plots of land surrounding taro patches are cleared by slash and burn. Practically all of these areas have been previously cultivated at one time or another. Some areas are ditched, mounded-up almost vertical, and sometimes lined with stone for sweet potatoes and yams. Ditches 2-12 feet wide and 1-5 feet deep orient plots 10-50 feet wids and 25-150 feet long. Mounds are elevated with soil from the ditches for each successive planting. These gardens are cultivated for usually no more than two years, then left fallow for at least five years.

Drier and less fertile upland soils sustain only a limited variety of crops. Most such areas have also been previously cultivated, usually for sweet potatoes and cassava, and were ditched, mulched and mounded. For new plantings the tops of the mounds are tilled over, sometimes mulch in the form of undecomposed grass is added. The landscape soon resembles old World War I trenches. These areas are typically cultivated for one growing season and abandoned for much longer durations than are the lowland gardens.

Some field crops are seasonal and many gardeners plant by the new and full moons. If the site is burned it is usually not necessary to weeed for several months; then weeding is done by hand. Expensive commercial fertilizers are rarely used. Leucaena slash or palm fronds are the common forms of mulch. Insect pests are sometimes smoked out. The shifting rotation pattern probably does much to alleviate major insect and disease problems. Women, young and old, tend the family gardens. Village neighbors often communally clear and establish garden sites, then divide the area into family plots. This farming system is labor intensive, but the energy inputs are low.

Cultivation practices in ancient times can only be surmised. High population levels must have pressured the land tremendously. Practically all of the accessible land in the Western Carolines was at one time or another cultivated, and fallow durations were presumably shorter. Much of these areas are now savanna and grassland.

Low coral atolls are most hostile to agriculture. Salt spray detrimentally affects most field crops and forest cover. Gardens must be established on the leeward side of the islands or protected by shelterbelts. The soils are almost entirely calcium carbonate, excess amounts of which, or arguably the lack of iron (Weins, 1962), causes chlorosis in most plants. Applications of mulch, iron salts, and possibly the burying of junk metals under the garden surface (Sproat, 1968) may alleviate this condition.

Atolls with over 100 inches of rain are most conducive for crop production. Those atolls which receive less rain are subject to prolonged droughts, at which times the incidence of salt water intrusions into the fresh water lens are more likely. Sea water in the taro patches affects the growth and taste of the crops. Mortar taro pits on some of the atolls have been constructed to remedy this situation. They are constructed on top of the ground then the soil medium is added. Even so, most atoll inhabitants rely on USDA rice and canned goods imported from district centers.

The non-traditional farming practice most frequently seen on the high islands is mechanized site preparation of upland farms. While this means farms can be larger, cleared faster, and facilitates construction and maintenance of firebreaks, most bulldozing is done improperly. The use of improper equipment and techniques results in the removal of precious topsoil. As the farms become larger, monocultural, and perpetually cultivated, they lose their beneficial relationship with the forest. This horticultural policy is prevalent with many local administrators. Present agriculture extension work on Yap, for instance, concentrates on bulldozing, and yearly "production" tallies are cited in the amount of land cleared. Many plots, unbeknownst to extension agents, are converted to house sites, so these figures are suspect.

AGROFORESTRY CROPS

Taro

Nearly all Pacific islanders use taro as an important food plant. In Micronesia, taro is considered to be the most important starchy food crop. Cyrtosperma chamissonis or giant swamp taro is grown in the largest quantities, and is one of the few taros that thrive on atolls. Elsewhere in the Pacific, Colocasia is the predominate species.

Giant swamp taro is one of the largest plants in the world to yield an edible corm. Some attain weights of 200 pounds. This crop can be planted in any season, allowing continuous harvesting and planting in a single patch. Tubers are not usually stored, but if kept moist can be preserved for up to one month.

Patch sizes vary from old bomb holes to several hundred square yards; some of the larger plots may be shared by several families. Taro patches are usually located near the village of the owner(s) and are not fenced. The islands have few destructive animals, pigs are either tethered or caged, and carabao are controlled.

Colocasia esculenta, otherwise known as elephants-ear or sweet taro, is considered to be the best tasting taro. Truk and Kosrae lead in its production. It is unfortunately subject to corm rot which destroyed most of the crop on Belau in the late 1800's. It is also susceptible to Phytophthora, a leaf fungus most serious on Pohnpei. Unlike Cyrtosperma, it must be harvested and replanted anually.

Honolulu taro (Xanthosoma sagittifolium) was recently introduced into the Pacific from the West Indies and Central America, and has become very popular. It is well suited for a variety of soils, but does not thrive on atolls. The corms are relatively insect and disease free, and can be stored for several months.

One of the most common taros is Alocasia macrorhiza, or wild taro. The corms of Alocasia are produced above ground, and can reach lengths of six feet. The corms contain calcium oxalate crystals, a mild, bitter tasting poison which irritates the skin. Most Alocasia species are used only if no other starchy foods are available. Samoa has introduced a variety from New Guinea which is nearly free of this chemical and it has become a staple food.

All taros have about the same nutritive value. They are high in calories; have moderate amounts of vitamins, minerals and carbohydrates; and are low in protein and fats. However, since serving sizes are usually large, most of an islander's daily protein requirements can be derived from taro. The taro leaves are an abundant source of calcium, and vitamins A and C, although Micronesians do not consume them in quanties that other Pacific islanders do. Taro and its greens eaten with fish, coconut and vegetables provide a fairly balanced diet.

YAMS

The yam (Dioscorea spp.) is an important food crop throughout the tropical lowlands. On Pohnpei it is important to the title and feasting system. A man's esteem grows with the size of the yam he produces and with each contribution to these rituals.

Yap and the Marianas also make extensive use of yams. They are usually grown on man-made trellises, or planted under trees with the vines trained to grow up the trunk. These plants produce 15-20 pound tubers and an acre can yield 10-15 tons of tubers. Yams are seasonal crops, planted November-February and harvested 9-12 months later. They can be left in the ground until ready to eat, or harvested and stored.

Sweet Potatoes

The sweet potatoe (Ipomea batatas) is the only economically viable member of the Morning Glory family. The only other menber of this family of any importance in Micronesia is kang kang (Ipomea aquatica), a nutitious cooking green. The sweet potatoe has high food value. It is easily grown and matures rapidly, particularly on land that has not produced this crop for several years.

Cassava

Cassava (Manihot esculenta) is the starchy food group of least import to Micronesians (Henry, 1982), though it ranks high among Belauans. It is very hardy and in many states grows wild. Cassava plantations produce high yields. Unfertilized plots produce 3-6 tons/acre; fertilized, the San Salvadore variety yields 11 tons/acre on Pohnpei. This crop is exteremly nutrient demanding and plots must be rotated and composted to maintain soil fertility.

There are two kinds of cassava, "bitter" and "sweet". The bitterness is caused by hydrocyanic acid, a toxic and acrid chemical in the tuber. Cassava is also known as tapioca and manioc, although tapioca specifically refers to the fine starchy product derived from the juice after pressing the tuber. Cassava is protein poor, though the young leaves are a good source of minerals. Both tubers and greens are fed to stock.

Bananas

Bananas are one of the most common fruits in Micronesia, and are eaten ripe or cooked when mature green. Of the several dozen varieties and strains, only three meet commercial standards: the Williams Hybrid in all of Mocronesia; Lacatan in the high islands; and the Dwarf Cavendish in the Marshalls. They are mainly intercropped with other foodstuffs. Monoculture plantations are few and usually no more than 1/3 acre. Yapese growers, for instance, may recieve $0.50/pound for quality banana produce destined for export to Guam.

Pandanus

The pandanus, or screwpine, has a hardy seed and is widely distributed throughout the tropics. While the edible type of pandanus (Pandanus tectorious) is found in both the Caroline and Marshall Islands, it is much more important to the Marshallese.

There are over 100 Marshallese panadnus cultivars. They can grow without freshwater and are not affected by saline ground water. The pandanus provides thatch material, wood for light construction, and twine (from the roots). The edible fruit is nutritious and even the flower bracts are eaten. On the drier atolls where breadfruit (Artocarpus incisus) fails to grow, the edible pandanus is an important part of the diet.

Both fresh and cooked fruits contain 14-18% carbohydrates, and less than .05% protein and fat. They are a good source of most vitamins and, though relatively low in ascorbic acid (approximately 2.5mg/100gm), they are eaten in such large quantities that they become an important source of vitamin C. The fruit is used to prepare flour, paste, juice and candy.

Breadfruit

The breadfruit tree (Artocarpus altilis, Fosberg) is a relative of the fig and mulberry. It produces best on well-drained soils where rainfall is high and temperatures warm. Some varieties grow well on coral atoll soils. There are many varieties in Micronesia, more than 70 in Truk and Pohnpei districts (Sproat, 1968) where it is a major subsistence food crop. It is also an important food crop in Kosrae and the Marshalls; it is found to a lesser extent on Yap and Belau and is little used in the Marianas.

Breadfruit is usually propagated by suckers. Depending on the variety, it can bear fruit almost any time of the year. The mature fruit averages three pounds and can be dried in the sun, boiled, or cooked and made into paste that is fermented and can be stored for months. It is low in protein, fat, vitamins and minerals. The tree's sticky latex pitch is used in caulking canoes in the outer islands.

Coconut

Obviously, the coconut is the most important plant in the Pacific. Its various attributes will be expanded on in subsequent chapters.

Secondary Crops

Other garden crops include: arrowroot, avacado, egg plant, pineapple, pumpkin, squash and various legumes introduced by Europeans which are very popular on Guam (pigeon pea, peanut, hyacinth bean, winged bean and *Vigna* spp.) (Barrau, 1961). The vanilla orchid of commerce (*Vanilla fragrans*, Salisb.), *Eugenia aromatica* (L.), nutmeg (*Myristica fragrans*), *Cinnamomum zeylanicum* (Bl.), *Pimenta dioica*, and *Piper nigrum* Linn., have been introduced to Pohnpei with varying degrees of success (Sproat, 1968).

Overstorey and ground flora of noteworthy importance include: *Barringtonia edulis*, betel nut (Yap and Belau), *Bruguiera sexanula*, chillies, *Citrus* spp., ginger, guava, Indian almond, jackfruit, mango, mint (*Ocimum sanctum* Linn.), papaya (often considered a prolific weed, used mainly for pig feed on the Western Caroline Islands), passionfruit, *Piper betle* (Yap, Belau and the No. Marianas), polynesian chestnut, rambutan and soursop.

Most of these species have been naturalized and can be found throughout high island forests. With the exception of coconut, breadfruit (Truk and Pohnpei), betel nut and pepper leaf (Yap and Belau), and some ornamentals, these plants are not intentionally propagated. The Yapese will indirectly incorporate these species into their cropping scheme by preserving residual plants in and around the garden site. They do not, however, plant marketable tree crops within their gardens. Small nondescript tree saplings are sometimes left on site as "examples for the crops", something akin to the Taungya system. Small garden sizes allow quick natural regeneration from neighboring forest cover.

TABLE I. FSM FOOD CROP PRODUCTION 1980 (Henry, S., R&D, FSM)

CROP	TOTAL PRODUCTION (lbs)	ACREAGE UNDER CULTIVATION	
Coconut	18,000,000	40,000	(17,600,000 lbs exported)
Banana	2,300,000	6,500	
Wetland taro	760,000	500	
Dryland taro	600,000	400	
Yams	5,000,000	-	
Cassava	2,000	-	
Sweet potatoes	100,000	-	
Vegetables	300,000	-	

COMMERCIAL PROSPECTS

Copra and Fruit

Copra is the main export commodity both in tonnage and income. Between 4/82 and 4/83, Yap and its outer islands exported 760 tons, generating over $100,000 in cash income and wharfage fees (Acker, 1984). In 1980, Truk district exported $1.9 million in copra; Pohnpei exported close to $1.7 million; and the Marshall Islands exported $2.6 million in coconut oil and copra cake (GAO, 1983).

There are at least 40 coconut varieties in the Yap district alone. New varieties are often brought to the outer islands from long canoe voyages. Heavily stocked acreage fetches crops worth approximately $200/year. Yields can be expected to increase 25% by culling old, densely stocked groves, and replanting with superior varieties. Though market prices fluctuate as much as 50%, copra will continue to be the single most important cash crop.

All Western Caroline fish and produce exports are conveyed to Guam. Yap citrus, banana and betel nut exports totaled $24,000 in the period 10/82 - 9/83 (Acker, 1984). Banana and betel nut accounted for 90% of this total. Export markets are generally more favorable for orchard crops than field crops. Fresh fruit command higher prices, but with quarantine restrictions, processed or juiced produce may be more saleable. There are conflicting recommendations regarding the development of a fruit industry in Micronesia. The Feasibility Study FAO: Central Fruit Processing 1980, concluded that such a project was "viable" but would require annual subsidies beyond the range of investors (somewhat contradictory).

Insect and disease place serious and immediate constraints on agricultural development, especially on Guam. Most of its produce is banned in Japan (the largest potential market) because of quarantine restrictions, notably pertaining to the melon fly. The most feasible agricultural strategy for Guam would be to concentrate on import substitution crops and on the 290,000 Japanese tourists that visit the island every year desiring such fruits as papaya, mango, oranges and pineapple. Problems other than quality control that need to be addressed before establishing a large-scale produce industry are:

1) Land supply (Recently the government of Guam has leased arable public land at cut-rate prices.)
2) Irrigation (Guam and Saipan)
3) Training of farmers
4) Industrial infrastructure: processing
5) Market coordination between the farmer and internal/export markets

Unlike Guam and Saipan, the FSM's political status along with the bargaining power of their fishing rights and war claims, enables them to take advantage of Japan's Generalized System of Preference (GSP), provisions providing trade preferences and market access (Japanese Ministry of International Trade, 1985). Although there are no exemptions from plant and quarantine regulations, insects and disease are not as problematic in the FSM as in the Marianas. Conveyance via air freight is easily arranged. Though charges are somewhat high, negotiations are under way to give Micronesians more of a controlling interest in Continental Air Micronesia and subsequent rates could be adjusted for development related activities.

Specialty Produce

With a few exceptions, traditional Micronesian cuisine is fairly bland. Recently, specialty produce including fruits, vegetables and spices has become very popular among both natives and tourists. Family managed cottage industries could supply many of the demands. Since most land is tenured in small, scattered plots of low production volume, specialty items of relatively high mark-up potential that can be readily assimilated into contemporary gardens are appropriate. The best example of marketing this type of produce is the black pepper that is grown and packaged on Pohnpei. Propagating on a larger scale many of the previously mentioned secondary crops would be the practical start. Exampls of processing include soursop drinks, wax gourd "ice cream", and jam made from various flowers.

Rattan

A "minor" forest species that is already generating enthusiasm in Micronesia, though it is not found there, is rattan. Rattan is fast being depleted in the Philippines as one of the most sought after species by the Philippine cottage furniture industry, and as the most important forest product after timber.

Of the four genera found in the Philippines, two are of commercial interest: Calamus ornatus v. philippinensis Becc., and C. merrillu Becc. A number of other species produce good canes but are not collected because they are difficult to distinguish from other less suitable species. The Philippines have been approached regarding procurement but, since their supplies are dwindling, they are not anxious to export such a scarce resource. The only other source of stock may be Indonesia. Although Indonesians have had commercial success in rattan cultivation, they have produced no literature specifically dealing with the technology.

The most promising substitute stock is bamban (Donnax cannaeformis), a perennial herbacious plant commonly found in the Philippines. It grows in open areas, thickets, under secondary growth and on coconut plantations. Stems are gathered and made into splits just like rattan, then bleached in the sun. Bamban can be made into the same kind of products as rattan, and may be more site compatible for Micronesia. There is a Donnax species found in the understorey in Belau, but unsure if it is the same variety (Falanruw, 1985).

Animals

The main rationales for animal introduction would be their utility in converting and storing excess crops as well as produce unfit for human consumption, and as sources of protein, manure and labor. Animals are not directly incorporated into traditional farming practices, but a few species are of commercial and ceremonial value. There are cow herds on Belau and Rota, grazing on open grassland, which are not systematically rotated along with any crop. This is not a feasible development alternative for the rest of Micronesia.

The Norway, Polynesian and black rat has undoubtedly had more of an impact on the environment and economy of most Pacific islands than any other animal. They are a copra producer's worst threat.

Guam has had some successful introductions such as the Sambar deer (Cervus unicolor), feral pig (Sus scrofa), and the Asiatic water buffalo (Bubalus bubalus) which is also found on Pohnpei. Goats have been introduced in the largest numbers on Pohnpei with limited success; they can be destructive in the wild. Goat introduction is rightfully on hold in the rest of the FSM. Most poultry projects have met with little success because of imported feed costs, disease and fiscal irresponsibilities. The crux is obtaining disease resistant layers, for there is a demand for broilers and eggs. Raising pigs is the most popular animal husbandry activity. Many families in the FSM own one or two pigs, which are fed copra and food scraps.

An agroforest industry that would assist the development of poultry and piggery projects is the establishment of local feed mills. The technology is inexpensive, not overly technical, and could benefit many farmers. Such an enterprise would:

- expand internal matkets for surplus foodstuffs,
- reduce the reliance on expensive imported feed,
- improve the diet and finishing times for local livestock, thus increasing animal production and providing a substitute for imported food.

A feed mill on Guam is back in operation after a long hiatus. The factors that led to its closure (low user demand, exclusive production of poultry feed, and expensive importations of raw materials) should not arise on the high islands of the FSM.

AGROFORESTRY RESEARCH and DEVELOPMENT POTENTIAL

Agroforestry is a field relatively new to researchers and resource planners, though it has been successfully practiced by the people of the Pacific for hundreds of years. It encompasses several disciplines, and often the appraoch to research and development is fragmented. Regretfully, agroforestry does not receive adequate support from most forestry and agricultural institutions. The basic premise of agroforestry, biological diversity, gained rapid acceptance in both disciplines, but they seem to diverge when diversity requires integrating with one another.

Because agroforestry is primarily a subsistence endeavor, there are few economic motivations for its inclusion in U.S. curricula. Support for small, individualized ventures are limited.

Large-scale plantations are mostly monocultural in either forestry or agriculture, and production is channeled mainly to high paying external markets. Corporate institutions operating on a cost/benefit basis invest in these land use systems. Internationsl corporate funding for subsistence research and development is limited. Not suprisingly, R & D in the tropical Pacific is concentrated on commercial export crops. Conflicts between commercial and subsistence development arise when the production of commercial crops inflate the price of goods in the local market or when resources are limited to begin with and a choice has to be made between the two.

Ecological information on the dynamic of both natural and man-made ecosystems have been indispensable for rational management. Such information is needed to discern the useful limits of any resource base, and to accurately predict the outcome of any given management practice. Specifically, agroforest research in this region needs to address several criteria for improving land use:

o Identify tree species that can be combined with desired field crops so as to:

1) Enhance the growth of field crops,

2) Improve soil fertility,

3) Produce quality merchantable timber, and

4) Yield other products of value.

- o Ascertain optimum spatial arrangements of tree and food crops under varied environmental conditions (based on such factors as: productivity, energy inputs, labor requirements, compatibility with mechanized tending, insect and disease protection, etc.).
- o Deduce suitable crop rotations that prolong cultivation durations (maintaining fertility, erosion control, retarding the incidence of insect and disease, coordinating phenologic relations to changes of the seasons).

Much of the historic knowledge of native plant life, including the local names, uses and folklore, is being lost. This information has been traditionally passed from generation to generation by word of mouth, little has been recorded. A computerized compilation, in the form of an index and key, of the native flora of these islands would be a significant asset to local communities. Database management software makes it possible to permanently file the total inventory of plant life, and pertinent information about each species. Most local governments have computer hardware installed, making capital investment small. This project has been intiated on Yap, by the Yap Institute of Natural Science (YINS).

Education

Most U.S. higher education expertise in resourec management is employed by land grant universities, and there are few such universities situated in environments similiar to those found in this region. There is no influential constituency calling for such research, so there is no basis for funding. Hence, little attention is given to agroforestry.

Micronesian states also confront the problem of student and vocational attrition. Regardless of studies, few students who receive training in the U.S. return to work in the occupation for which they were trained. There are few job opportunities back home, especially in the private sector, for graduates of such training.

Presently, agroforestry research is conducted in the region only at the YINS, an independent organization headed by a part-time USFS Biologist. An agroforestry curriculum needs to be established in a central Micronesian location. This way training in resource management can be attuned to local social, technical and economic environments. By supporting appropriate research on various islands, the institution could begin to address regional problems. The University of Guam seems to be the logical location since much of the infrastructure is already in place. Meanwhile, data will continue to be pooled from various organizations such as: ICRAF, South Pacific Commission, FAO, AID, USFS, East-West Center, and the Nitrogen —Fixating Tree Association.

If qualified expertise ia available and able to formulate valid research proposals, it may be plausible to solicit grants from some U.S. corporations and consortiums which finance research in agronomy, forestry and nutrition (e.g, Kellogg and Ford Foundations).

R & D Goals

The single most important objective of technical agroforestry research is to provide superior stock. Without this, newly acquired propagation techniques cannot be fully effective. This is especially true of tree crops where the initial choice is often irrevocable. Genetically breeding disease-resistant, salt and drought tolerant crops, or the acquisition of the same, is most pertinent. Tissue culture yechnologies can be applied toward some of these aims (COSTED, 1982) and may be very cost effective.

There is a definite need for research in improving, diversifying, and promoting crops for local consumption. Food markets in most of the Pacific are inundated with polished rice, unenriched flour and soft drinks. These nutrient-scarce commodities have replaced many superior foods. It will take a combined effort by government agencies, educators and private business to reverse this trend.

These territories have environmental and economic advantages over many other countries where tropical agroforestry is practiced. Settlements are permanently established; poulations, though increasing, are still low; and there are regular infusions of subsidies. The main "problem" with agroforestry is that it is not employed to the extent it could and should be.

In areas where agriculture is declining, education and wholesale promotion of this practice are needed. Again, a concerted effort is needed by local agriculture and forestry agencies, educators, and policy makers. Tax incentives can be given to businesses that replace imported produce with local goods, and farming supplies could be exempt from local taxes.

Agriculture extension must be prioritized. This service should collaborate with any centralized higher education development. This ensures the extension personnel are trained and informed of applicable technologies. Such efforts are, of course, aimed at the rural areas, which comprise most of the islands. But with growing populations and increasing maigration into the district centers, urban areas must enter into any plan to reduce imports.

In most urban areas of the Pacific there are small gardens, but they usually receive little or no attention from government extension services, despite their economic and nutritional values. It is difficult to accurately assess the economic impact of urban cultivation, but it must be substantial. Unproductive lots can be turned into gardens and augment the menus of government sponsored programs such as schools, hospitals, old age programs, jails, and the like.

It is not as critical to focus on urban agriculture in Micronesia. With the exception of Guam and Koror, urban populations are not high. Capital center populations are increasing, however, from 29.1% of the total population in 1967 to 34.8% in 1980 (GAO, 1983). As they increase further, urban agriculture will presumably become more important.

Suggested Improvements

Intercropping multiple-use trees, preferably nitrogen-fixating and quality sawtimber species on larger plantations, will enhance sites and provide usable peoducts. Planted in rows that divide the field crops, the trees are lopped and pruned, providing mulch for field crops or used as fodder, thus allowing more sunlight to reach the field crops. Tree rows are eventually rotated with the cultivated crops. The trees planted around the perimeter grow to their full height providing merchantable timber as well as a wind and fire-break.

This land use system should extend the duration of continuous crop production on the same site (ICRAF, 1983). This would be labor efficient over the long-run, and environmentally favorable since extended cultivation will reduce the need to slash and burn other areas. It will also make possible use of perennial crops. Piggery and poultry enterprises need large, sustained production of cassava, copra meal, dried fish, kang kang, and taro leaves for local feed. A pig requires four pounds/day, or over 700 pounds of feed to reach finishing weight (Thavalingam, 1985). This necessitates larger, more intensively managed farms.

Even the traditional shifting farming system can be improved. As the field crops are sowed on smaller areas, multiple-use trees can be planted. This will expedite the succession to forest cover with quality timber. When it is time again to plant field crops, these trees can be harvested instead of burned.

An extension of this reclamation practice would be the sowing of perennial grasses or legumes to be tilled under future field crops or used as forage. This forage is also harvested or at least utilized in the garden, further reducing the need to burn. Ground cover between field crop sequences reduces the risk if insect and disease infestation of future crops.

Implementation

Each component of the farming system should make an economic contribution, or it may not be accepted; environmental contributions are often economically beneficial, but not readily apparent. The timber aspect is the easiest to sell. Farmers can easily envision the uses of posts, sawtimber and fodder. The use of ground cover, on the other hand, may be resisted, especially if the farmer must procure his own stock. The farmer will probably have to see substantial yield increases demonstrated elsewhere.

Island resources are interconnected, requiring an interdisciplinary approach to their utilization. The principles of agroforestry make land use management flexible. This is a desirable asset when dealing with varied conditions and objectives. A comprehensive, integrated program can be cost effective. Local infrastructural facilities and services (roads, harbors, airports, communication, electric power, agriculture storage, equipment and resource agencies) are established and can accomodate these programs. Gratis labor for private land development in the FSM should be supplied by the land owner (a case where extended families has its merits) in exchange for government efforts (equipment, stock and personnel). Outside expertise will be needed for some training and supervision, in addition to genuine commitment from local administrations. Basically, agroforestry will just be an integration and training of existing local services.

FOREST RESOURCE ASSESSMENTS

BACKGROUND

Because of their diversity, natural tropical forests are not as readily managed as temperate forest stands. There have been few instances where viable silvicultural practices have been successfully transfered to mixed tropical forests. When profits are based on production per unit of land, natural diversity is a drawback. The usual practice throughout the tropics, therefore, has been to replace natural vegetation with plantations of introduced species.

In Micronesia, non-timber forest resources are currently more important than timber. The primary uses are, and will continue to be in the near future, agriculture and watershed retention. The following is a brief synopsis of the major forest resource uses and their potential for development.

TIMBER

Logging is confined to the selective felling of scattered trees. Logging opportunities are limited due to diverse forest compositions of poor-quality timber, low merchantable volumes and rugged terrain. On the atolls, felling is restricted to Calophyllum and breadfruit trees for canoes and local construction. Most high islands have small stands of mahogany, teak, Adenanthera and eucalyptus (Belau), established during the early Japanese and American administrations. For the most part, there are only scattered species of top quality timber, not enough for sustained yields. Pohnpei and Kosrae contain the best residual inventories (primarily of Terminalia spp.) of all the islnads, a couple of sawmills, and the greatest potential to augment imported sawtimber with locally produced lumber.

There is a demand for quality sawtimber; most district centers in the FSM import in excess of 200,000 bdft of lumber per year (not including plywood) (Acker, 1984). Such production could be locally attained mainly through pioneer timber plantations and enrichment planting on the high islands of the Western Carolines.

Pioneer timber plantations on the more favorable grasslands is the most feasible approach to this goal. There should be a combination of fast growing, muliple-use pioneers (both nitrogen-fixating to help ensure survivability and reclamation, and quality sawtimber) and slower growing but higher quality trees for long-range returns. Fast growing pioneers such as Pinus caribaea v. hondurensis could provide short-term cash crops as Christmas trees for export to Guam. (Success of this particular alternative hinges on a suitable mycorrhizae inoculation. On Yap and Guam this tree's performance has been substandard). The strategy of planting in the grassland and marketing thinnings throughout the rotation will mitigate the effects of intensively managing the natural forests. Selecting trees that coppice will expedite regenaration making management more energy efficient; and termite resistant timber will be more merchantable.

If high-quality naturalized species are available it is a good plantation practice to trial them along with the exotics. They are already proven, and older islanders seem more receptive to planting familiar species. Many islanders, however, are quite enthusiastic about planting new species. Exotic trees provide a "WOW!" factor in forestry. In fact, some exotic trees we established in plantations on Yap were dug up and pirated away. Of course, the main concern in introducing exotic species is the potential for them to become troublesome weeds. It is imperative to thoroughly know any introduced species. Pioneer timber species are not as risky in this regard, since most cannot surivive in a closed forest.

Initially, only the best grassland sites should be identified for plantations. The future reception of this phase of forestry could depend on the success of the first few plantations. The more denuded a site, the more "nurse species" (primarily of reclamation value) are needed to rehabilitate it, and timber returns are diminished. Enrichment planting in the forest would have the advantage of better site conditions, but would probably be limited to agricultural sites, relatively small areas that could not come close to plantation yields.

An immediate potential for timber stand improvement and processing is in coconut tree trunk utilization. Coconut wood and woven palm leaves have traditionally been used in tropical countries for structural framework and thatch. Modern imports of softwood sawtimbers and corrugated iron have replaced most of these traditional materials. This change was in part necessitated by the spread of the rhinocerus beetle (Oryctes rhinocerus) which breeds in felled and decaying coconut logs. Because of this pest, coconut wood cannot be used in contact with the ground, and proper disposal of the residue, which provides potential breeding sites, is critical.

The threat of the rhinocerus beetle, coupled with the need to thin and replant old unproductive coconut groves, spurred the technology of coconut stem utilization. Making old growth stems a useful commodity further encourages land owners to cull old growth palms and replant.

The coconut palm is a monocotyledon and differs from the dicots of conventional forests. The palm stem does not increase in diameter by the thickening of the cambium, and conductors are concentrated in the soft center. This leads to a great difference of outer and inner densities, requiring special sawing, seasoning and preservation procedures and equipment. Research is proceeding on the various possibilities of exploiting palm stems for:

structural supports, power poles, sawn lumber, particle board, charcoal, pulp and paper (Wellington Ministry of Foreign Affairs, 1976). There is a need to scale down some of the production costs to enable exploitation at cottage industry levels.

ENERGY

The energy demands in Micronesia are increasing, but small; aggregately importing 5.8 million barrels of petroleum fuels annually (excluding jet fuel). The cost to local governments is high. Metered rates, if there are any, usually have no correlation to the cost of production. Local governments often subsidize use by more than 50% (GAO, 1983). Given the policies of not actively seeking bill collections, this can rise to 100%.

TABLE II. The American Territories of the Pacific, with population, land area, electricity demands, and preliminary assessment of biomass (wood) potential. (Brewbaker, 1983).

LOCATION	POPULATION	TOTAL LAND AREA (ha)	PEAK LOAD (MW)	BIOMASS POTENTIAL
Guam	120,000	55,400	155.0	Good
American Samoa	32,400	20,000	13.3	Poor
CNMI	16,860	47,000	14.5	Good
Marshall Is.	31,000	18,100	4.3	None
Belau	14,800	49,400	3.1	Fair
FSM				
Truk	38,650	30,600	3.1	Poor
Pohnpei	23,480	29,000	2.3	Fair
Yap	9,320	11,900	1.2	Poor
Kosrae	5,520	10,900	0.3	Fair

Fuelwood, inclusive of coconut husks and shells, is the most plentiful and least expensive source of energy in Micronesia, and on most atolls is the only source. Most of this fuel is used for cooking and sometimes for repelling insects from house and garden. Charcoal is not widley used though species that make excellent charcoal (Leucaena spp., casuarina and mangroves) occur commonly on the high islands. Charcoal has several advantages over most other forms of local fuel: it burns relatively smokeless and has a high heating value and raw materials are ample.

It may be possible to utilize the vast mangrove areas a a fuel source in the commercial production of katsuobushi, a kind of fushi produced from skipjack (Katsuwonus pelamis). The katsuobushi manufacturing process includes boiling, smoke-drying and possibly moulding skipjack fillets. Marketing outlooks are favaorable. Japan has an insatiable demand for fushi. The Japanese katsuobushi industry absorbs 50% of all skipjacks landed, and imports an additional 1,500MT.

The investment profile seems lucrative. A small-scale factory processing 500MT of tuna produces 90MT of finished product, using 35MT of firewood purchased at $115/MT; requires an investment of $62,750, with sales of approximately $2,300/MT of final product FOB (van Eys and Mizuishi, 1983). Also, the FSM has an abundant source of skipjack, and preferential trade agreements with Japan.

Mangroves are the species of choice for fuelwood having high specific gravities and caloric content (particularly Rhizophora mucronta). There are high volumes of accessible stands. The main harvest concern is soil erosion. Conservation measures must be applied so that the resource stays renewable. This entails hatvesting proper volumes, achieving appropriate final spacings, taking into account tidal influences, and ensuring regeneration.

Due to the traditional land tenure on most islands, direct supervision by local agencies of this resource will be difficult. But it is imperative that qualified personnel demarcate harvestable areas and individual trees. This should be a prerequisite for the sale of this resource to government agencies.

Conversion to wood-fired electric plants is not foreseeable in the future. Labor and capital investments are generally higher for fuelwood plantations than for conventional stands due to higher stocking densities (often 20-40 times as high) which in turn affect the cost of seedling production. More elaborate harvesting and processing methods are also required. Converting electric plant facilities and adjusting existing grid sizes would also be costly. If keeping the cost below 5.6 cents/kWh is a condition of staying economically viable (Mayer, 1983), then Saipan is the only feasible location for such conversion (based on land and fuel availability). To even consider the conversion, an additional 8,100 ha of fuelwood needs to be established (Brewbaker & MacDicken, 1982).

Biogas digesters can provide some energy to small-scale livestock farmers. They convert livestock wastes to biogas containing 2/3 methane gas (CH_4) and about 1/3 CO_2 with traces of sulfides. This gas is produced and stored continuously for cooking, lighting and small refrigeration units; the effluents are used for livestock and aquatic feed, and for fertilizer. However, initial costs are somewhat high ($1,000-1,500/unit).

FIBRE

The only noteable indigenous fibre resource is the coconut husk, from which coir fibre is made. It is manufactured by hand on a limited scale. There are no processing facilities in Micronesia. Substantial volumes could be produced on the high islands, Truk especially, and could probably compete with synthetic fibres.

There are numerous restraints on plantation production of fibre. Most fibrous plants (e.g., jute, ramie, and kenaf) require fertile soils, putting them in competition with more proven resource uses. Markets would be limited as competition from cheap synthetic fibres is strong. Mechanized processing is required to mitigate the drudgery involved in production, adding to capital costs. Expanded fibre production would be a dubious proposition for Micronesia.

TRADITIONAL SPECIALTY PRODUCTS

The forest has always been a source of specialty products. Banana fibres, coconut fronds, and hibiscus are the raw materials for grass skirts and older men's garments. Dyes for clothing and tattooing are made from several species of plants. Two plant species are used in the preparation of the most important traditional beverage on Pohnpei, sakau. The roots of *Piper methsticum* are macerated and water is added as the pulp is kneaded by hand. It is then placed on strips of *Hibiscus tiliaceus*. The juice is wrung out, ready for consumption.

Betel nut chewing is an ingrained habit on Yap and Belau. The nut of *Areca cathecu* is split open, mixed with burnt coral lime, then wrapped in a pepper leaf (*Piper betle*). Chewing releases certain alkaloids that intially give the unaccustomed chewer a little "high".

One of the most important, and ofetn well-guarded, local uses of endemic flora is in the production of medicines. Techniques have been documented in Pohnpei (Riesenberg, 1948), but on most islands this information is passed orally from parent to progeny. With westernization, much of this knowledge has been lost.

RARE and ENDANGERED SPECIES

Mnay of the native flora and fauna of these islands are fragile and often irreplaceable. Several species of both flora and avifauna are on the verge of extinction or have not been seen in years and can be qualified as extinct. This problem is most critical on Guam, where recovery programs concentrating on birds are carried out by the Guamanian wildlife biologists in conjunction with the U.S. Fish & Wildlife Service.

Guam's bird population has been declining for at least two years. The Solomon Island brown snake is responsible for the extinction of three bird species that were found only on Guam: the bridle white-eye, the fufous fantail and the Guam flycatcher. The Philadelphia Zoo, National Zoo, and zoos in Denver, New York and San Antonio have begun a "bird lift" and breeding programs to save three other endangered species: the Guam rail, the Micronesian kingfisher and the Mariana crow. The snake may have reached the island in the late 1940's accidentally in military shipments or intentionally to control rodents. Nobody knows. The snakes, which can attain lengths of nine feet but pose no harm to humans. are also blamed for numerous power outages by shorting power lines. Establishing bounties or a snakehide business have been suggested as ways to control the snake population.

Guam also has three endangered plant species: Cyathea lunulata, Heritiera longipetiolata and Serianthes nelsonii, and an additional 34 threatened species. Studies identifying the habitats and distributions patterns of these plants are needed to formulate a recovery and protaction program.

In the early 1980's Yap banned the hunting and exportation of fruitbats (the only indigenous land mammal). Populations had been drastically reduced through exports to Guam, where the bats are considered a delicacy. The ban is still in effect as the fruitbat population continues to recover.

Quarantine procedures are of paramount importance to this region. Over the past 10-15 years harmful insects and plant diseases have been introduced at an alarming rate, as access to these islands has become easier and as the islanders themselves have traveled more and more. The two most harmful introductions have been the rhinocerus beetle and the African snail, which now populate many islands. Guam has been particularly hard hit since, as the hub of Micronesia, it has the most visitors and international commerce, thus the greater chances of infestation. A very recent introduction that threatens some forests on Saipan and Guam is the Psyllid, an insect that feeds on the new growth of Leucaena spp.

Upland forest and agroforest development will: curb wildlife habitat loss by alleviating pressures to exploit the natural forests; add to this habitat through grassland reclamation; and help maintain the gene pool. Proper utilization of natural resources, particularly the mangroves, ensures habitat preservation. Natural parks or reserves, and creating enforcement agencies to assist the preservation of endangered flora and fauna is only feasible where there are large tracts of public land (Guam and Saipan are the only possible candidates). Furthermore, this management practice is not warranted because of the circumstances surrounding bird decimation and the lack of user demand for the natural forests.

OUTDOOR RECREATION

Most recreational activities center around the island's beautiful ocean settings. Guam and Saipan contain some splendid inland areas that are well promoted. Tourism development in a few states of the FSM is still controversial, as they try and retain their culture while managing a steady influx of tourists. Lack of public land also hinders this development.

SUMMARY OF CONSTRAINTS AND MANAGEMENT OPPORTUNITIES

SOCIO-ECONOMIC ISSUES

Socio-economic issues in Micronesia present some hurdles to resource development. A major concern has to be the rapid movement from traditional subsistence-type living to a predominately white-collar lifestyle. Guam showcases some of the attitudes and norms that can develop when a culture comes to rely on imported subsidies ($80 million/year) and consumable goods, and how, in turn, this affects resource development.

The cost of living is high on Guam. The economy is based on employment by the local government (over 40%), the U.S. military, and the tourism industry. The island's resources are only slightly utilized; surveys show that less than 2% of the land is actively cultivated. It seems that agricultural pursuits have become mere hobbies, despite the high cost of imported foods. People have grown accustomed to the convenience and high social status associated with these products. Profit margins do not seem substantial enough to warrant private investment in endeavors that yield even short-range returns. (Recently, the government of Guam allocated 3,000 acres of arable land for lease to private cultivators, pro-rated at $40/acre/year, and there were only 30 takers.) An inflated wage structure reduces the chance that agriculture commodities could in the future compete in either internal or external markets.

Government assistance in the form of welfare and food stamps has become a way of life to many young Guamaniains. In 1984, 19% of Guam's population received food stamps each month; 7% received welfare cash, up from 4.3% in 1975. Average monthly benefits for a family of four amount to $1,100. Extended families act as a social welfare system throughout Micronesia and can play a small part in hindering private development initiatives. A large percentage of any profit derived from a project is apt to be parceled among many not-so-industious relatives.

Recruiting exceptional forestry students is difficult; the forestry profession is not too prestigious and qualified faculty are scarce. Because of the population's affinity for government jobs, Guams education system is oriented primarily toward preparation for white-collar work. These jobs lure people, especiallly the young, to the cities, which further encourages imports. Increasingly, Guamanians are selling their land to outside interests, a practice abhorrent to most other cultures of Micronesia.

Few agriculture workers in the humid tropics put in an 8-hour day; more commonly four or five hours constitute a day's work. Acquisition of temporary jobs for immediate monetary goals are common. This complicates training and supervision, and results in low productivity. These social attributes are by no means confined to Guam; to a lesser extent they are found in all of Micronesia.

TECHNOLOGY IMPLICATIONS

A higher quality of life will be realized neither through toatl economic development nor through a "return to nature". These territories are in a position to receive substantial federal appropriations, and there will be an emphasis on economic development. Improved land use, environmental protection and economic development do not have to be mutually exclusive if policy makers make appropriate development decisions.

The resource specialist in this region has few opportunities to directly mananage resources because of the scattered, varied nature of the islands, land tenure and socio-economic conditions. Ultimately, the resource planner must be able to stimulate land owners into developing their land by applying proper management techniques. The government developer will not be a caretaker, but a consultant, educator, intercommerce liaison or broker, and quasi-salesman of applicable R & D technologies.

Many forestry and agroforestry technologies are economically sound and socially acceptable in this region and would benefit islanders in a variety of ways. Development objectives and methodologies are based on three general environmental headings: prime arable high island sites, degraded high island areas, and the atolls. They should include both subsistence and cash generating projects such as: the establishment of timber plantations providing sawtimber, foodstuffs, fodder, handicraft materials and specialty products; the enhancement of traditional farming practices, planting materials and cottage industries that utilize agroforest products; and the reforestation of denuded land for later exploitation.

Because of the isolation and harsher environments of atolls, applicable technologies for these areas are limited. Agroforestry should become a priority since food shortages are often acute. Appropriate goals include the provisions of salt and drought tolerant subsistence crops; mortar pits for taro; coconut grove rehabilitation; and the introduction of site compatible timber species for general construction, canoes, fuel and handicrafts.

Possible beneficial economic, social and environmental implications of further use of forestry and agroforestry technologies include:

- more jobs, direct & indirect
- increased income & standard of living
- better income distribution
- cheaper food
- better nutrition
- adaptation to a variety of production preferences
- easily transferable, not highly technical

- applicable to both domestic and export markets
- environmentally sound
- use of agricultural cooperatives & lobbying
- low energy input requirements
- utilize abundant & inexpensive resources

PRIORITIES FOR APPLYING RESEARCH AND DEVELOPMENT

I. AGROFORESTRY

    A. Species Selection

        1. Procuring and testing superior stock

    B. Nursery Management

        1. Seedling care
        2. Vegetative propagation
        3. Micropropagation

    C. Agrisilviculture Extension

        1. Enrichment planting (intercropping small traditional gardens)
        2. Upland tending practices (larger, slightly marginal sites)
        3. Coconut grove thinning and replanting
        4. Atoll subsistence crop research and development
        5. Public conservation education

    D. Product Utilization Technologies

        1. Coconut stem and fibre
        2. Canning/processing/preserving industries
        3. Charcoal/fuel production
        4. Biogas

    E. Insect and Disease Control

    F. Marketing

II. AFFORESTATION

- A. Species Selection
  1. Sawlog
  2. Reclamation
  3. Foodstuff
  4. Fire and wind breaks
  5. Fodder
  6. Alkaline conditions
- B. Plantation Mechanics

III. NATURAL FOREST MANAGEMENT

- A. Mangroves: fuel
- B. Estuary Protection: pollution and run-off
- C. Wildlife Habitat Protection

EFFECTIVE INSTITUTIONAL ACTIONS AND IMPLICATIONS

Local Institutions

Throughout Micronesia, forestry and/or agroforestry development programs are a low priority. The few goals discussed have been given little more than lip-service. Forestry personnel are often siphoned off to perform non-forestry tasks. Some state forestry expenditures are prodigous, yet produce few results (e.g., for fiscal year 1982, Guam spent $250,000 in forestry, "developing" 75 acres mostly concentrating on grass-fire suppression). Even this outdistances the meager production of the forestry programs of the FSM. Yap is the only state to actively establish pioneer timber plantations on private land. Due to budget constraints the forestry program was managed under the auspices of a federal job training program and not through the government's Division of Agriculture & Forestry.

Although local governments are ultimately responsible for prioritizing their own development needs, they can be strongly influenced by outside institutions. Dr. Winfred Biddier in Potentials of Economic Activities for the Outer Islands of Yap, 1984, recommends the introduction of cashew as a cash crop to eventually supplant coconut trees; the planting of corn, sorghum, millet and rice; papain production; and turkeys, to the outer islands of Yap. Unfortunately, this proposal has caught the fancy of many Yap legislators.

Biddier presents no documentation to support his premise that such species could survive in such a habitat (though papaya is naturalized and cashew would grow, the other introductions would be doomed). He focuses soley on speculative economic forecasts of no technical merit. The resulting development and the elimination of the coconut trees would not only be unrealistic but catastrophic, and yet, it has its local advocates.

Due to the nature of forestry programs, local administrations must commit themselves to long-range support. This is critical in nursery management, propagation trials and plantation tending. Under the terms of the Compact of Free Association, the majority of funding will be received in the first five years. FSM officials at the national and state levels noted that they do not have sufficiently trained staffs to appraise, monitor and evaluate the projects proposed for funding in the first five years of the Compact (GAO, 1983).

Independent research in Micronesia is hampered by the lack of local, competent expertise. Yap is the only state in the FSM that has a privately funded research organization, the YINS. This organization is able to carry on independent research and conservation education activities that are interdisciplinary in nature or beyond the scope of most local agencies.

The policies of local development-lending institutions are contrary to their objectives. The Economic Development Loan Fund requires 120% collateral for private development projects. (The Bank of Hawaii, in comparison, requires 80%.) Thus it is nearly impossible to secure financing for large ventures. If the private sector is to be involved in economic development, it is obvious that these rates need restructuring.

The FSM has few legal trade incentives, restrictions and price controls (although copra prices are subsidized). As local commodities are reliably produced, import quotas and price controls of their import counterparts should be established. Import restrictions on some foods of dubious nutritional value should be considered.

U.S. Federal Agencies

Many U.S. agencies have contributed valuable management assistance to this region. The Soil Consevation Service, et. al., completed extensive soil surveys for each state in the FSM and Belau, and can provide soil analyses at the University of Hawaii. The U.S. Fish & Wildlife Service surveyed each state's bird populations, and helped coordinate Guam's endangered species recovery program. The U.S. Forest Service (USFS) should complete vegetation mapping by 10/85, and has donated nursery materials to various islands.

The USFS is the most logical U.S. agency to assist this region in forestry development. There are, however, several issues that need to be addressed before assistance can be truly effective. First, most Micronesian contact with the USFS is with the USFS-IPIF, based in Honolulu. Its priorities (biomass research) are not those of the Micronesian isles. Thus the available training and services are not often transferable.

The USFS training program in Guam (6/85), for example, focused on fire suppression, with an emphasis on arson investigation. The instructors were well qualified but such training is not appropriate in Micronesia. The FSM forest assessment, conducted by the USFS, focused on merchantable timber (expressed in timber weight). Since data are accumulated from several locations, classifications and descriptions tend to be very broad, and some native attributes are not fully described (e.g., endemic acacia stands on Guam were overlooked). While some of these statistics may be useful to some states (Kosrae and possibly Pohnpei), the survey will not have much of a bearing on local land use planning. R & D must be relevant to the locale and culture for which it is intended, and at this stage should not be too technical. Otherwise, the local communities will become disenchanted and it will be difficult to garner support for future programs.

The USFS does not have sufficient staff to provide specific land use assistance, information dissemination services, and stock and germ plasm sources. There is only one part-time biologist versed in agroforestry in the region, with no agroforestry research pending. If the USFS could expand their services to include agroforestry development, agriculture insect and disease control, and coconut tree utilization technologies, it would have much greater and more positive impact in this region. Because of their international connections, AID and the East-West Center are in better positions to act as information exchange services. Since the USDA extension programs are the sine qua non of this type of service, once a centralized higher education system is developed it would be prudent to seek their assistance.

U.S. Congress

The dominate influence wielded by the U.S. Congress is its control over the distribution of support funds. There are stringent guidelines for federally administered programs, but the FSM will not be eligible for these funds once the Compact is ratified. The dispersion of funds is most critical at the local level, and influence at the Congressional level will become nil.

Adoption of trade provisions allowing duty-free entry into the U.S. of products deriving more than 50% of their finished value in Micronesia, along with other tax and finance incentives, may attract U.S. and foreign investors. Foreaign investment is currently concentrated in fish storage, transhipment, copra processing, hotels, airlines, and petroleum distribution. These trade provisions will probably produce a small textile industry, but have little impact on agroforestry.

Congress can indirectly assist agroforestry development in U.S. territories by supporting international organizations that perform agroforestry research (e.g., ICRAF and SPC). It would be most efficient to support the YINS, which is already established in the region.

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TABLE I. FSM Food Crop Production 1980. Henry, Sailas. Div. of R & D FSM.

TABLE II. The American Territories of the Pacific, with population, land area, electricity demands, and preliminary assessment of biomass (wood) potential. USDOE, 1981 & Brewbaker, 1983.

TABLE I. FSM FOOD CROP PRODUCTION 1980 (Henry, S., R&D, FSM)

CROP	TOTAL PRODUCTION (lbs)	ACREAGE UNDER CULTIVATION	
Coconut	18,000,000	40,000	(17,600,000 lbs exported)
Banana	2,300,000	6,500	
Wetland taro	760,000	500	
Dryland taro	600,000	400	
Yams	5,000,000	-	
Cassava	2,000	-	
Sweet potatoes	100,000	-	
Vegetables	300,000	-	

TABLE II. The American Territories of the Pacific, with population, land area, electricity demands, and preliminary assessment of biomass (wood) potential. (USDOE, 1981 & Brewbaker, 1983).

LOCATION	POPULATION	TOTAL LAND AREA (ha)	PEAK LOAD (MW)	BIOMASS POTENTIAL
Guam	120,000	55,400	155.0	Good
American Samoa	32,400	20,000	13.3	Poor
CNMI	16,860	47,000	14.5	Good
Marshall Is.	31,000	18,100	4.3	None
Belau	14,800	49,400	3.1	Fair
FSM				
Truk	38,650	30,600	3.1	Poor
Pohnpei	23,480	29,000	2.3	Fair
Yap	9,320	11,900	1.2	Poor
Kosrae	5,520	10,900	0.3	Fair

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TABLE I. FSM Food Crop Production 1980. Henry, Sailas. Div. of R & D FSM.

TABLE II. The American Territories of the Pacific, with population, land area, electricity demands, and preliminary assessment of biomass (wood) potential. USDOE, 1981 & Brewbaker, 1983.

INFORMATION UPDATE & REVIEW

This section updates and reviews the major conclusions of two referenced OTA materials (Whitesell, 1982, OTA commissioned paper; and OTA report, 1984) on forestry practices and plans in the U.S. affiliated Pacific islands. Analyses will concentrate on areas where opinion differs, similiarly held views are detailed in other sections of this paper.

Whitesell, et al. 1982:

By in large, forest deterioration is not a serious issue [A.1]. Their recommendations for creating and strengthening enforcement agencies and related regulations would be both futile and inappropriate since most of these islands have little public lands. The legislative ban on hunting and exporting Yapese fruitbats, for instance, only worked because the local government controlled the customs and quarantine operations - it had little effect on local harvests. Natural parks or reserves is again, only feasible where there are large areas of public land (which Guam & Saipan are the only possible candidates). And user demands on these environments do not necessitate this management practice.

Deliniating and identifying public lands and assigning management responsibilities has long been accomplished, and hardly needs the USFS or any other international organization's assistance in this regard. Improving fire suppression capabilities [A.1-d] is not cost effective. Passive, indirect methods incorporated into plantations with a vested interest is much more practical. Stabilization schemes [A.2] by themselves (e.g. fuelbreak plantings) are not as productive and salable to the public as multiple-use plantations. A well designed and maintained forest plantation is in itself a fuelbreak, and able to produce many more benefits than a single purpose shelterbelt around grassland.

Determining growth and yields of native forests [B.1-b] needs to be clarified, detailing what particular species or vegetation type and why. Data on agro-forestry yields, mangrove growth rates and regeneration traits (for possible fuel production) are the only commercially viable aspects of the natural forests that need to be quantified. Studies of other aspects would be hard to justify. Enough background information exists to put together appropriate site-specific management plans without first resorting to "growth plots" of man-made plantations. This type of terminology should be stricken from any implementation proposal using private land. The project may be a pioneer, and plantation sizes may be small and likely considered "test plots" elsewhere, but it may be all the land the owner has and to refer to his plantation as a test is more than discouraging.

Technology transfer demonstration areas [B.3-a] in the immediate future would do well to emphasize agro-forestry, especially when the management practices will be different than present methods (e.g. large, integrated upland farms). The rotations are shorter and management more intensive compared to that of pure forest stands, expediting educational opportunities. Since most forest plantations will be geared to the open grasslands, they'll automatically become demonstration areas. Identifying land use alternatives does not have to be as high tech as implied [B.4-a]. There are relatively few land use options anyway, computerized models do nothing to expand them. Again, there is sufficient data available to resource planners regarding appropriate agro-forest technologies that they may be able to start applying them, rather than developing new ones. It seems incongruous that the USFS would start developing new agro-forest technologies when they haven't yet adequately researched effective native farming practices under their jurisdiction [B.4-c].

The reasoning of recommendation [C.4-b] "providing bare-foot or paranaturals with generalized training that would qualify them to assist both permanently assigned and visiting scientists conduct their work..." goes against the grain of self-sufficient development strategies. It will only perpetuate the attitude of locals that most outside institutions are self-serving, using these islands as their own personal laboratories. Under this set-up, local input is only realized in the implementation phase of the planning process, when they're asked to provide land, labor or disperse information emanating from an outside source. They are asked to serve outside institutions. Any institutional training should go through the appropriate local government channels, if they exist, to provide training to personnel so that visiting scientists may assist them.

Background Paper No. 3

CONGRESSIONAL ACTION TO IMPROVE THE SUSTAINABILITY OF U.S. TROPICAL FOREST RESOURCES IN THE PACIFIC

by

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I. U.S. TROPICAL FORESTS IN THE PACIFIC

The United States' tropical forests in the Pacific are located in Micronesia and in American Samoa. Micronesia covers 3 million square miles in the Western Pacific north of the equator, 2200 miles southwest of Hawaii, and extends westward to within 500 miles of the Philippines. More than 2000 islands are found in this vast area, and range in size from small, unoccupied coral atolls to large volcanic islands supporting thousands of people. American Samoa, the only American territory south of the equator, is 2300 miles south of Hawaii, and consists of seven islands with a total population of 30,000 people.

Reliable information on the original extent of the forests on these islands does not exist. Most authorities believe that forests comprised the original cover. On many islands, prime examples being Guam and Siapan, destruction by both man and nature has left the islands in such changed conditions that it is nearly impossible to identify their original forest cover types.

Micronesia includes the Marshall Islands, the Caroline Islands, including Kosrae, Ponape, Truk, Yap, and Palau, and the Mariana Islands (Guam, Rota, Saipan, Tinian, and the northern islands). The tropical climate of these Western Pacific Islands is characterized by high humidity, considerable cloudiness, and rainfall ranging from 80 to 200 inches annually. During most years, there is a rainy season from June through November and a dry season from December into June. Typhoons usually occur during the rainy season. December and January are the coolest and most pleasant months.

There are considerable differences in the topography among the islands. For example, the 10 northern islands of the Northern Marianas are rugged, high islands—some with active volcanoes. The southern islands of the Marianas have both large limestone terraces and volcanic slopes. In the Caroline Islands the high islands of Babelthaup and Peleliu in Belau and Yap, Truk, Ponape, and Kosrae in FSM have coastal flats and steep interior mountains. Low islands and coral atolls are also common. The Marshall Islands are all low islands or atolls.

Specific data on the resources, land area, vegetation distribution and condition are inaccurate and in many cases not available. The Forest Service, in cooperation with the Soil Conservation Service, has conducted a joint soil and vegetation survey of the Trust Territories, and maps and reports will start appearing in the Spring of 1983. A summary of geographical and demographical data is presented in Table 1.

Table 1—Geography of Micronesia

Government	Population (1980)	Land (acres)
Territory of American Samoa	32,400	49,200
Territory of Guam	110,000	135,000
Commonwealth of Northern Marianas	16,900	
Saipan		29,810
Tinian		25,066
Rota		21,124
Federated States of Micronesia		
Yap	8,200	27,875
Ponape	22,300	90,000
Kosrae	5,500	26,270
Truk	37,500	20,950
Subtotal	(73,500)	(165,095)
Republic of Palau (Belau)	11,800	108,300
Republic Government of the Marshall Islands	25,000[1]	17,945
Total	269,600	551,540

[1] 1973 data

Ecosystems of Micronesia and Samoa[2]

1. FORESTS: Closed stands of trees at least 16 feet (5 m) tall, usually evergreen and neither cold nor drought resistant.

1.1 Lowland Rain Forests

Biotic Provenances: Mariana Islands and Caroline Islands

Composition: Usually composed of numerous fast-growing species, some mature stands exceeding 100 feet (30 m) tall, generally with smooth, often thick bark, some with buttressed lower boles. Emergent trees often present or at least form a very uneven canopy. Very sparse undergrowth composed mainly of young trees. Palms and other tuft trees usually rare. Crustose lichens and green algae are the only constantly present epiphytic life forms; vascular epiphytes are usually not abundant except in excessively humid situations.

1.2 Montane/Submontane Rain Forests

Biotic Provinces: Samoa and Caroline Islands

Composition: Emergent trees largely absent and canopy relatively even. Vascular epiphytes and pseudo-lianas abundant. Tree heights usually less than 130 feet (40 m); crowns extending relatively far down the stem. Bark often more or less rough. Undergrowth abundant and often represented by treeferns, small palms, or bamboos. May be dominated by trees which are broad-leaved (commonest), small-leaved, or needle-leaved.

1.3 Bamboo Forests

Biotic Provinces: Mariana Islands and Caroline Islands

Composition: Dominated by bamboo. Occurs in the mountains, but may be present in lowlands.

1.4 Cloud Forests

Biotic Provinces: Samoa, Mariana Islands, and Caroline Islands

Composition: Trees are often gnarled with rough bark, and rarely exceed 65 feet (20 m) tall. Most commonly broad-leaved, but may be small-leaved or needle-leaved. Tree crowns and trunks, and lianas, are burdened with epiphytes--mainly bryophytes or lichens.

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[2] from Dahl, A.L., 1980

1.5 Riverine Forests

Biotic Provinces: Samoa, Mariana Islands, and Caroline Islands

Composition: Similar to submontane forests, but richer in palms and undergrowth species, especially tall forbs (e.g. Musaceae). Trees frequently have buttressed boles.

1.6 Swamp and Bog Forests

Biotic Provinces: Samoa and Caroline Islands

Composition: Similar to riverine forests, but relatively poorer in tree species. Boles of many trees are buttressed, stilt roots, or pneumatophores; mostly taller than 65 feet (20 m), and dominated by broad-leaved trees or palms.

1.7 Mangrove Forests

Biotic Provinces: Samoa and Caroline Islands. Of very limited extent in Guam and the Marshall Islands.

Composition: Sclerophylli broad-leaved trees, some species with stilt roots or pneumatophores. Occurs in tidal areas along shorelines and estuaries. Epiphytes, except lichens and algae are rare.

1.8 Atoll/Beach Strand Forests

Biotic Provinces: Samoa, Mariana Islands, Caroline Islands, and the Marshall Islands.

Composition: Species poor community of trees and shrubs occurring on calcareous sand and rubble deposits on islets and coastal beach strand near sea level.

2. WOODLANDS

Biotic Provinces: Mariana Islands and Caroline Islands

Composition: Formed by open stands, with most tree crowns not touching, but covering at least 30 percent of the ground surface; trees at least 16 feet (5 m) tall; and grass or shrub cover sometimes present.

3. SCRUB

Biotic Provinces: Samoa, Mariana Islands, Caroline Islands, and the Marshall Islands

Composition: Mainly composed of woody shrubs up to 16 feet (5 m) tall; crowns may or may not be touching, the former often with a grass substratum.

4. DWARF SHRUB

Biotic Provinces: Mariana Islands and Caroline Islands

Composition: Closed or open cover of woody plants rarely exceeding 1.5 feet (50 cm) tall. When open, often in clumps or colonies; and may have forb or grass cover in open areas.

5. SAVANNAS

Biotic Provinces: Mariana Islands and Caroline Islands

Composition: Grasslands or parklands with trees and/or shrubs covering not more than 30 percent of the ground.

6. GRASSLANDS

Biotic Provinces: Samoa, Mariana Islands, Caroline Islands, and the Marshall Islands.

Composition: Grasses with little or no woody vegetation.

7. FOREST PLANTATIONS

Biotic Provinces: Samoa, Mariana Islands, Caroline Islands, and the Marshall Islands

Composition: Man-made forests of native or non-native tree species of pure or mixed composition.

II. HISTORICAL OVERVIEW OF FOREST USE

Pre-U.S. Administration

The original inhabitants of Micronesia made few modifications of the ecosystems that had evolved on these islands. Then forests began a gradual decline following the arrival of the Spanish on Guam, some 300 years ago. As the Spanish, and then the Germans gained control, many of the islands were eventually cleared, primarily for coconut plantations. The Germans also introduced teak, kapok, and a few other forest tree species during their administration during the period 1887-1914 (Bascom 1946). Then in 1914, the Japanese occupied nearly all of the Micronesia Islands except Guam and a few small islands. Within a few years, the Japanese aggressively created a new social order on the islands. All lands suitable for agriculture were cleared and new crops such as pineapple and sugar cane were introduced. Copra production was increased. Forests were cut for lumber and charcoal. Thousands of laborers, tradesmen, and their families, came from Japan and Okinawa. Refineries, packing plants, large towns, and fortifications were built. Agriculture and forest experiment stations were established and research conducted, including studies on nitrogen-fixing legumes and forest tree species introductions. Most of these developments were destroyed during World War II and the Japanese were sent back to their homelands. Commercial agriculture ceased and most of the fields have remained unproductive. They are covered with brush, grass, or trees, and are degrading from erosion and fires. By the middle of this century, most of the forests of Micronesia had been, at some time either destroyed, cut over, or converted to agriculture. On some of the islands, there remain isolated stands of large trees that were not harvested because of inaccessibility. Many of the forests are now recovering and approaching merchantable size. Unfortunately, these forests are often comprised of species of limited utility and few possess commercial value.

U.S. Administration

Administration of forest resources in Micronesia has been conducted by several federal agencies; the U.S. Navy, Department of Interior, Territory Governments, and now the emerging semi-independent governments. During the 37 years of American control, there has been a mixed bag of "managers" of the forest resources inherited from the previous administrators. There have been, at various times, American foresters, agriculturists, biologists, conservationists, military planners, and local island foresters, initiating or conversely ignoring forest management practices; and conducting forestry related research studies. Political changes, turnover in personnel (transition from American expatriate officials to native leadership and the use of short-term trainees; i.e., Peace Corps volunteers; position vacancies; and administrators with non-forestry backgrounds) have eventually negated much of the constructive work started over the years in Micronesia. Other factors have also played important roles in determining the present condition of these forest lands, including World War II destruction, fires, typhoons, vandalism, timber theft, neglect, noxious weeds, impoverished soils, and inadequate funding of conservation programs.

One of the more successful U.S. supported efforts in Micronesia has been the work of the agriculturists. Specialists seem to have come and gone over the years, but a dedicated core accomplished some important work, on limited budgets. They were also handicapped by limited research facilities and staff. Technologies such as those available through the United States Agency for International Development programs to lesser developed countries, were seldom funded to any real extent in Micronesia. As a result, for example, a lack of knowledge of soil nutrient deficiencies, and crop nutrient requirements exists.

The condition of coconut plantations on many islands is of serious concern. Many were planted by the Germans around the turn of the century and they are now senescent. The varieties planted were not high yielding and even if younger, could not compete with other copra producing areas.

The TTPI agriculturists brought thousands of superior coconuts to the Marshall Islands and to other islands from the Yap Islands, in the 1960's. However, this coconut rehabilitation project was never completed. The local economies now suffer and two new copra processing plants, one in the Marshalls and one in Palau, have had low production and profits because of a copra shortage. In fact, it has been necessary to import copra from New Guinea to keep the Palau plant operating.

One indirect socio-economic impact upon the forest resource, especially agroforestry where coconut is the primary crop, is the U.S. free food program. The merits of this program are argued constantly (Rody 1982). It cannot be disputed that this program has been and is needed on certain islands to maintain the well-being of the local residents. However, it is rightfully argued that these food programs have or are destroying the islanders' initiative and will to work. Candidates to public office have been defeated when they took an anti-free food program position, declaring that a decline in farming and fishing was resulting in a loss of basic subsistence knowledge and skills. Claims have been made that copra production has fallen where free roast beef, rice, and other staples have been readily available in almost unlimited quantities.

Land Ownership Patterns [3] [4]

With the Micronesian islands spread over thousands of miles of the Pacific, it is not surprising to find many different forms of land ownership. These varied ownership patterns relate to the influence of the old Spanish, German, Japanese, and present American administrations. This leads to many large and small land ownership disputes today. These disputes are of major importance to the status of some forest lands, especially the mangroves. Are they government owned, or are they controlled by the villages? If government owned, there is a much better chance for sustained management. This is highly unlikely if controlled by individuals or chiefs. Mangrove ownership disputes will eventually be settled in the courts.

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[3] From Sprout and Migvar, 1964.

[4] Personal communications from Sprout and Migvar, 1982.

Ponape and Kosrae States

The ancient system of land tenure and inheritance is not entirely clear for Ponape State. It is thought that land inheritance was undergoing a gradual change from matrilineal to patrilineal or when the German administration accelerated the individual title process. The present day land tenure has been modified by foreign rule towards that of the modern western method. However, it still retains some emphasis on total family subsistence. The new inheritance laws as passed by the Ponape Congress in 1957 allows that (1) children of either sex inherit land in preference to all other relatives, (2) all children should be given some land if there is enough available. Other members of a family group may inherit land under certain circumstances.

The German government in 1912 instituted a land reform which gave the common people actual deed-holding title to their land. Deeds were issued to all those people who occupied land that was primarily worked for the benefit of the high chiefs. Hence, individual ownership of land predominates on Ponape Island and to certain extent on Kosrae State. The atoll land tenure patterns are primarily extended family ownerships, with all members having specified use rights to various tracts.

Sale of land is becoming quite common on the two high islands of Ponape, but is seldom practiced on the atolls. The Japanese acquired large sections of land for cassava, sugar cane, and coconut plantations. They developed a 2,500 acre coconut plantation at Metalanim. All of this land is government owned and is being divided into three hectare homesteads. All but about 500 acres of the former Japanese coconut plantation at Metalanim has been surveyed and homesteaded.

Most of the Trust Territory inhabitants live in villages and commute to their land to do the necessary work; however, the Ponapeans are the exception to this system. They live in scattered farmsteads throughout the island. The only large town is Kolonia, where the majority of the able-bodied men work for the government. Living on scattered farmsteads is probably the carry-over of the ancient custom of each man having a secret plot of land to carry out subsistence farming for himself and family.

Truk State

In Truk land may be owned individually or by family lineage groups of close to extended family members. Truk society is mostly based on matrilineal descent; however, this has been somewhat modified in recent times especially when one deals with land inheritance. In the Truk Lagoon some islands have a number of bilaterally and patrilineally constituted land holding groups.

The major types of land recognized by the local inhabitants are dry land, fresh water swamp, and areas covered by shallow sea water. Improvements on any of these areas may be owned separately from the land itself. In other words, items such as breadfruit trees, coconut trees, food plants, buildings, and stone fish weirs are improvements and may be owned separately from the land if occupancy has been properly authorized. The size of individual pieces of property are quite small, seldom more than a few acres. A person usually has some interest in a half dozen or more plots, but not necessarily a sole interest. On family land, single trees or small clumps of trees may be owned by a single individual.

Interest in real property is acquired from one's extended family or lineage, from one's parents, from another as a gift, from another by purchase (with goods, labor, or money), from marriage plus several other minor methods such as war spoils, discovery, breach of marital relations, caring for the sick and from a wrong doer. The outright sale of land varies widely within Truk State. There have been sales to foreigners which were usually done under protest and misunderstanding. The early traders acquired land in exchange for trade goods, the result being that the offspring of the traders own large sections of land.

Yap State

The most important form of property in Yap is land, almost all of which is controlled by the local inhabitants. Land not only provides subsistence and building materials, but also determines the Yap Islanders' status and role. A man becomes a chief or magician because of the particular land he holds. This traditional unit of land is an estate or tabinaw, a word which is synonymous with that for family or household. An estate consists of all the land belonging to a single extended household. Estates include one or more house platforms, taro pits, sea inside the reef, stone fish weirs, coconut palms, yam gardens, grassy uplands, and timber lots.

The tabinaw land is the joint possession of all males and unmarried females of a single patrilineal household, all of whom have a voice in its disposal. The actual authority is vested in an estate head who is usually the eldest male in the local lineage. He is the trustee of the tabinaw lands because of his age, maturity, and seniority. He is expected to provide each member of the extended family with land plots sufficient for their subsistence.

The Yapese people follow the patrilineal pattern as far as land inheritance is concerned. Their inheritance patterns stress the continuity of tabinaw land ownership from father to eldest son. It is most important that the tabinaw estate be kept intact. This system prevents fragmentation of land parcels, yet provides use rights for the entire extended family. Sale of land as practiced in the western world is practically unknown in Yap.

Republic of Palau

The transfer of land in pre-contact times came about in several ways: through defeat in warfare, by a clan being assimilated by another clan, by exchange, and as payment for an offensive action. It is very doubtful that land was ever sold outright in pre-historic times. Actual sale, along with individualized ownership, began during the German period and was accelerated during the Japenese period. The governments and colonists of the two nations were the buyers in most cases. Some land titles are transferred by the Palauans today.

The most significant change in Palauan land tenure has been the adoption of individual land ownership. The introduction of individual ownership precedes German times, but its true significance and effect came to be realized during the Japanese period. Legal recognition was given to this form of ownership by the Japanese land registry. Contemporary concepts of land control, use right, exchange, sale and inheritance are extremely involved largely due to the complexity of Palauan social organization and the changes it has undergone in the past century.

Commonwealth of the Northern Mariana Islands

During the first 150 years of contact with the Spanish, the Chamorro culture became more and more westernized with the consequent breakdown of the old social organization. During this same early period the aboriginal land tenure system became modified towards individual ownership of land. After the Chamorros resettled in Saipan in the latter part of the 1800's each family cultivated its own fields, thus individual ownership was firmly established. During the German period, land holdings became quite orderly when the German authorities recorded all titles to land holdings of individuals, and issued certificates of title to each person's property. At this same time a homestead program was begun and some Chamorros from Guam moved to Saipan to take advantage of it.

The division of family lands which began during the Spanish times continues to this day. This division is called a partido which is accomplished just before the death of the male parent. This type of an inheritance pattern tends toward fragmentation of land holdings and if carried to an extreme results in such small parcels of land that a family is unable to provide itself with enough food. This fragmentation became quite serious during the Japanese period when nearly all good public land was absorbed by the sugar cane industry and individuals were unable to acquire more free land.

It can be said that land tenure patterns among the Mariana Islanders are more similar to the U. S. system than any other district of the Trust Territory. Even the sale of land is an accepted custom. The United States administration began to issue five hectare homesteads several years ago. Presently, 580 homesteads are in existence. Homesteading of public lands is being encouraged and is a continuing program. It has been noted that many applicants for homesteads have not implemented required improvements on the land, and are consequently denied title to the homestead.

Territory of Guam

About 80,000 acres of land or nearly 60 percent of the total area of Guam is in public ownership, both Federal and Territorial. The large military holdings, together with the small amounts of other Federal land, comprise about 52,000 acres. The Territorial Government of Guam owns about 28,000 acres of land. But there is a degree of confusion about the actual status and location of these lands. Most of this Government of Guam land is subject to reversionary restrictions. Land in private ownership totals about 55,000 acres. This is largely in the southeastern and central sections of the island. Private ownership is mostly in small parcels and titles are often clouded.

Republic of the Marshall Islands

The Marshallese system of land tenure provides for all circumstances and takes care of the needs of all the members of their society. The land is their social security, each new-born has land rights. In pre-contact times the paramount chief, that is, the senior ranking member of the lineage of the ruling clan, was the acknowledged owner of all the land. The general attitude today regarding land rights is one of joint ownership of land rights with the chief, who possesses certain rights while the commoners possess other rights and hold these rights as members of a lineage in common with the other lineage members. Specifically, the use of land is as follows: The head of a lineage, the Alab, or his representative is in charge of the land and the workers on the land. He collects a share of the food produced on the land as well as a share of the copra revenues. The paramount chief, who is the head of the ruling lineage, also receives a percentage of the money received for each pound of copra produced on the land.

A typical land-holding consists of a strip of land from lagoon to ocean and varying in size from about one to five hectares. Each land holding has its own name and history. The Marshallese system of inheritance of land rights is principally matrilineal. As mentioned before, every person is born with land rights. This land belongs to the clan and all members have use rights to certain area; therefore, individual ownership of land is practically nonexistent. Also, very seldom is land sold in fee simple; although during the German period the entire soil of Likiep and Ujelang Atolls was sold.

III. CURRENT STATUS OF THE FOREST RESOURCES

Present Extent

The present extent and condition of the forests in the American Pacific vary greatly from one island to the next. Some islands possess healthy, relatively young or to newly maturing forests, forests that have or are recovering from past exploitations; for example on Ponape. On the other hand, there are areas where the forests may never recover. As populations increase, island forests decrease. Land for food production has priority. It appears that some islanders remain more capable of existing under a subsistence agriculture system than others. Nevertheless, the need for increasing food production necessitates the conversion of the better and most accessible forest sites to agroforestry, and these areas eventually will be converted to fields, or if mismanaged, abandoned. If abandoned, it is probable that low quality scrub forests or grasses will occupy these sites. The local women are usually responsible for the growing of vegetables which necessitates the partial clearing of the forests. Their decisions determine the species composition of the forest.

Productivity

Micronesia's forests remain unmanaged and their productivity is relatively low. The "average islander" seems little concerned as imports seem to provide more desirable substitutes. Expanding populations are gradually generating the pressures that lead to conversion of the native forest to agriculture and urban areas. Eventually, the agricultural lands will be largely depleted of nutrients and will be abandoned. These lands and those already converted to non-productive wasteland or scrub forest eventually are designated "forest land." Foresters can only make such lands productive with great ingenuity and patience.

The U.S. Trust Territory of the Pacific Islands (TTPI) Government has contracted with the Soil Conservation Service and the Forest Service, USDA, for mapping the soils and vegetation cover types of the Republic of Palau and the four states of the Federated States of Micronesia. The field work has been completed and the soil and vegetation maps will be used in land use planning. The vegetation maps will be used to conduct the first forest resource assessment of the Federated States of Micronesia, by the U.S. Forest Service in cooperation with that government. The reports from this project will become available to government officials and the public in 1983. Similar assessments are needed elsewhere in the American Pacific to determine the extent of the forest resources, and to acquire information, currently not available, on forest growth, yields, and condition.

Guam - the Most Americanized Island

Guam has been an American territory longer than any other island in Micronesia (since 1898). It appears that the lives of the Chamorros prior to the arrival of the Spanish differed little from their neighbors in the Caroline Islands. The current status of the forest resources on Guam provides an insight as to what can happen to our other insular territories if certain events are permitted to occur.

Guam has a land area of about 210 square miles (135,000 acres). Its population is about 75,000. However, about one-half of the population is made up of military and Federal employees and their families. There are interactions between the civilian and military communities in employment, housing, and the use of public services and business establishments. It is estimated that about 50,000 people live in the civilian communities. Agana is the center of civilian population, civil government, and commercial activities, including tourism.

Before World War II the major means of support for Guam's population was subsistence and semi-commercial agriculture. Since 1950, military and other Federal expenditures have dominated a modern money economy. Many of the social and economic changes that have been stimulated are irreversible. Thus, as the population and labor force grows, a broader base of employment opportunities is needed. This will be especially true if Federal expenditures are unchanged or decreased. Most of the goods consumed in Guam are now imported.

The increased population places a burden on Guam's remaining natural resources. There is an increasingly urgent need to protect and manage these resources within the limits of sustainable yields. But there is also a need to fully develop the potentials latent in these resources to provide needed goods and services. The forest and related wildland resources in Guam could be developed and managed to provide greater yields of forest products and more recreation opportunities.

Very little land on Guam is intensively used. Towns and villages and the intensively developed portions of military reservations probably occupy less than 10 percent of the land. It is estimated that less than 2 percent of the land is actively cultivated, including small backyard subsistence gardens. About 70,000 unmanaged acres have a cover of brush or trees. This includes some 10,000 acres of coconut groves which are no longer tended for copra production, and are reverting to wildland. There are some 50,000 acres of open or grass-covered land, little of which is grazed. In the southern part of the island some of the open land is barren and actively eroding. Significant portions of the wooded and grass-covered lands are in the military reservations, and are used for military purposes, thereby restricting or preventing other uses.

Very little of the original forests types exist on Guam today, because man's activities over several centuries have greatly modified the vegetation. Changes have been accelerated during the last three decades primarily as a result of military activities. The main effect of man's activities has been to greatly reduce the extent of forest types. Brush and grass now occupy extensive areas previously forested. Another major effect has been to modify the species composition of forest and other wildland vegetation types. This occurs, for example, when fire eliminates species from an area, or when introduced species successfully compete for space.

Most of the forested land is in the northern limestone portion of Guam. Banyan or nunu (*Ficus prolixa*), wild breadfruit or dugdug (*Artocarpus mariannensis*), chopag (*Mammea odorata*), joga (*Elaeocarpus joga*), fago (*Ochrosia oppositifolia*), screw-pine (*Pandanus* spp.), hau or pago (*Hibiscus* tiliaceus), and coconut palm (Cocos nicifera) are the dominant species, the canopy seldom reaching 75 feet tall. In the southern part of the island tree types are mostly in stream valleys or ravines. Here, the same species prevail and with the addition of betel nut palm (Areca cathecu) and diog (Calophyllum inophyllum). Locally, tangan-tangan (Leucaena leucocephala) covers large areas. This tall shrub species generally occupies disturbed areas of limestone soils in the north and central parts of the island.

Large areas in the southern part of Guam, especially the volcanic uplands, are grass-covered or savanna. The dominant grasses are swordgrass (Miscanthus floridulis) and Dimeria chloridiformis. Scattered ironwood (Casuarina equisitifoilia) trees have become a dominant part of the cover in many places. Most of the grass-covered or savanna areas are highly flammable and burn frequently. These bunch-grass types are not good forage nor do they provide good protection to soils in the important watersheds.

Mangrove (Rhizophora sp. and Bruguiera sp.) swamps, nipa palm (Nipa sp.) swamps, and marsh types, occur locally at the shores or in river valley mouths.

There are many other native and introduced tree, shrub, and herbaceous species growing in the forests, savannas, and related wildlands.

None of the present forest types offer any significant potential for commercial timber exploitation because of low volume and poor quality of the trees. However, some local use is made of trees for posts, small construction timbers, and craft work.

Guam's present forests have value, however, especially as watershed cover. These forested areas also provide many attractive scenic and recreation sites and wildlife food and cover.

There is a need to improve watershed cover, develop a local fuelwood supply, and improve the wildlife habitat, scenery, and recreation setting. Improvements can be brought about through application of forestry practices.

The Government of Guam conducts various programs in agriculture, forestry, fish and wildlife management, and outdoor recreation. These programs are supported by federal funds.

At times, the military becomes concerned about the management of their forest lands. Fires are common in the highly flammable grass types and frequently burn large areas of the watersheds. Expensive improvements and facilities are sometimes destroyed. Vegetation destruction is followed by flooding, erosion, and siltation of the harbors. The U.S. Navy cooperates with the Guam Department of Agriculture in conservation projects. The objectives of these agencies are to decrease the incidence of fires and resulting fire damage, to improve watershed cover, and to develop and improve the forests for scenery, recreation, wildlife, timber, and timber related crops (Nelson and Whitefell 1969).

IV. IMPACTS OF CURRENT USES ON THE FOREST RESOURCES

Those with concerns for the sustainability of the forest resources of Micronesia and American Samoa need not look elsewhere for examples of the consequences of land mis-management; just look around and back in time at these islands. Here, nearly all the possible mistakes have been made one or more times. Nearly everything exploitable has been exploited within the last 200 years. A concerted effort is needed in the American Pacific to avoid repeating past mistakes, and apply what is known to save and improve the existing forest resources. In time, these islands can, in most cases, provide sustainable yields, but only for local needs. The rapidly increasing populations will consume any available forest products produced within short land or sea hauls. There is little potential for exports of wood products even with future increases in forest yields. Economic pressures on the newly elected and appointed officials of the territories and free, associated countries to generate dollars, should not involve a quick liquidation of those limited forest resources that do exist.

Present practices involving the U.S. tropical Pacific forest resources appear to be little changed from the past. There has been a decline in the rate of exploitation of the timber resource, for lumber since World War II. By 1950, much of the choice timber had been cut. The capability to process lumber has almost disappeared because of worn out or inadequate milling equipment, lack of capital, lack of sawmilling skills, and competition from U.S. and foreign producers. This lack of capability for sustained lumber production on these islands could be judged fortunate, for it may give the native forests time to recover. This situation could change quickly, however, as small, low-cost, efficient, portable mills are appearing on the market; and as government assistance for business loans and for training is made available. Most of the logging on public lands has been uncontrolled (Owen 1979).

The demand for locally-grown fuelwood is increasing because of increasing population and fossil fuel costs. Some towns no longer have readily available sources of fuelwood, although accessibility to more distant supplies is improving as better roads are completed. The availability, transport, and price of fuelwood can vary greatly from one island to another, and on any one island. The sustainability of a fuelwood resource is difficult to predict. Perhaps one-third of the people in Micronesia are landless, meaning they have left their rural lands and are concentrated in urban areas. They need an inexpensive form of energy for cooking. Improved charcoal technologies, suitable for small scale production, could make wood an important source of energy as it was under the Japanese era. This would provide a use for scrub forests. Such developments would attract the attention of the Japanese and other Asiatics, who would enthusiastically promote the export of charcoal to their countries. However, this type of commercial involvement should be avoided until it has been determined that the islands could meet their own needs on a sustained basis. It is likely that man-made plantations and woodlots would be required to achieve this.

Soil Erosion and Siltation

Soil erosion and siltation of the marine environment is the most serious impact of poor land use practices. Siltation has an adverse effect up on coral reefs which are made up mostly of hermatypic corals and coralline algae. Hermatypic corals exist to depths of about 90 m, but thrive best at shallower depths of 25 m or less.

Siltation results in turbid waters and the deposition of a blanket of sediment on corals. The light reaching corals is thus reduced; the zooxanthella cannot photosynthesize and their benefit to the coral is lost. In addition, light reduction may interfere with deposition of calcium carbonate. Edmonson (1928) studied the effect of darkness on 17 species of Hawaiian corals and found that after 18 days of darkness, more than 50 percent died, especially species of Pocillipora and Porites, common genera in Micronesia.

The tiny coral polyps normally filter the water for nutrients. Many can remove excess sediment from their surface by ciliary action. However, when the amount of sediment in the water increases, this ciliary action is inadequate and the corals are smothered. The vulnerability of corals to smothering varies with species. It is thought that those species adapted to living in clear waters such as the outer reef margin are less able to remove sediments from their surfaces and are therefore more easily damaged by siltation.

Planulae, the free swimming larvae of corals, need a hard surface to settle on. A soft, unstable shifting bottom produced by siltation would hinder their settling and thereby prevent the recolonization of silt-damaged areas by corals.

Damage to corals may contribute to population explosions of crown-of-thorns starfish (Acathaster plancii). Chesher (in Levin 1970) cites instances on Guam, Rota, and Ponape, where populations of this starfish increased sharply following blasting and dredging operations. The increased populations of crown-of-thorns starfish then destroyed more living corals.

Corals live within a salinity range of 21 to 40 percent (Newell 1959, Shepard 1963, Wells 1957). The addition of large amounts of freshwater runoff is damaging to them. The lowered salinity kills them outright, or causes internal injuries.

Sources of Siltation

The major source of siltation in Micronesia is surface runoff. Other sources include shoreline landfill operations and dredging operations.

Surface Runoff--Natural siltation in Micronesia is greatest around the high islands. Elevated watershed areas provide for the collection and acceleration of flowing water from the land to the sea. This water picks up loose soil and humus and carries all out to sea. Around the high islands of Micronesia, however, filtering zones remove sediments before runoff reaches the clear waters of the lagoon and reef. The coasts of many Micronesian high islands have mangrove forests, where sediments from the land are filtered out and chemically buffered. Large amounts of organic material accumulate and decay in mangroves. Another filtering zone often found near mangroves are expanses of seagrass meadows. The bottom of these areas varies from mostly silt on the inner margin to mostly sand on the outer margin. These seagrass meadows contribute a great deal to the filtering and settling of siltation which gets through the mangrove.

It appears that these elaborate filtering and silt-adjusted biotic communities that have evolved around high islands serve to stabilize much of the natural runoff from the land, if left intact. Unfortunately, little is known about the operation and carrying capacity of this system, its relation to nutritional levels of lagoon and reef waters, and their relation to fish nurseries and the coral reef community.

The activities of early inhabitants of the high islands no doubt increased levels of siltation above natural levels; however, whether by design, necessity, or both, their major land-based activities (largely agricultural systems) made minimal increases in sediment production.

On many islands, there are low areas just inland of the coastal strand of mangrove. These areas, probably swamp or marshland originally, can function as a sediment trap, allowing the sediment from higher areas to settle before flowing into the ocean. Island people have largely converted such areas into taro patches. In doing so, they have modified the species composition of the area to one which utilizes the natural system for food production, but does not change the area's function as a sediment trap.

Traditional agricultural activities further inland also made only minimal increases in soil erosion, and the islands of Truk, Ponape, and Yap present three strategies of food production with built-in measures for maintaining the vegetative cover on the soil.

On Truk, the steep, lower slopes have usually been converted into coconut-breadfruit agroforest. This produces food, while maintaining a cover of trees to protect and stabilize the soil. The native forests on the top of Truk's higher islands have, in some places, such as Fefen, Dublon, and Tol, been left to prevent soil erosion. The steepness of the open slopes below these forests indicates their effectiveness, and also their vulnerability, for if these slopes are not stabilized, the forested areas will be undercut and more devastating erosion will result. The seriousness of removing tree cover on such steep islands was tragically demonstrated in recent years when heavy rains resulted in a mudslide which took six lives.

The island of Ponape is high enough to create considerable orographic rainfall and more than 10,000 mm of rain per year is estimated to fall on upper slopes. Removal of vegetation cover under such conditions results in severe erosion. The Ponapean agricultural specialty, the growing of huge yams (Dioscerea spp.); however, provides for a continued vegetation cover. This activity is carried on in a diffuse pattern by men who plant yams below trees which they climb, to train the vines up the tree. Depending upon the tree species and the amount of sunlight filtering through its leaves, the tree may be injured so that it drops some or all of its leaves as the yam grows. Eventually, the yam vine covers the tree. After the yams are harvested, the tree may recover; if not, the open space is rapidly covered over by surrounding vegetation and erosion is minimal.

Yap Island is subjected to frequent storms and unpredictable rainfall. The forests have been "customized" for the production of a variety of foods. Many species of food trees are allowed to grow and their harvest alternated with produce from taro patches and yam gardens. Burning is used to open up small garden areas and to produce ash fertilizer under trees and bamboo patches. Curcubits generally grow rapidly and cover the ground as the leaves of the burnt trees or bamboo fall, opening a "skylight" in the forest canopy. Yam vines climb up the trees and bamboo poles, producing a higher cover as the curcubits are harvested and die back. These are replaced by slower growing crops. The result is multilayered protective and food producing vegetation, which after some years is allowed to go fallow so that the "skylight" in the forest canopy gradually closes.

In many areas, the natural or modified erosion has now been accelerated. Plumes of eroded soils are often seen near the mouths of many streams and drains in Micronesia. This runoff represents a lost resource, and becomes a problem of marine pollution by siltation. Activities which aggravate this soil erosion include burning, which removes the vegetative cover from hills; cultivation practices; and construction and bulldozing operations such as roadbuilding.

Land clearing operations are probably the biggest cause of soil erosion. When the vegetation of savanna lands is removed by fires, and the exposed soil degraded, the root systems of these fire-adapted species are left to hold the soil. A bulldozer removes not only ground cover but also the root structure.

Efforts to Reduce Siltation

In 1974, the Trust Territory Environmental Protection Board (TTEPB) addressed the problem of siltation by passing "Regulations Concerning the Control of Earthmoving and Sedimentation in the TTPI." This regulation requires that anyone doing any earthmoving activity, except agricultural or for housing, must apply for a permit. Since about 1975; however, projects done in the TTPI by outside contractors have been monitored by the U.S. Navy, which enforces existing laws. At first, these regulations were neither widely known nor enforced, at least on Yap, as evidenced by projects such as the construction of the hospital, when large amounts of soil were bulldozed directly into the water. The U.S. Army Corps of Engineers also cooperates with environmental health workers in enforcing regulations in coastal areas. Since the Navy began enforcing regulations on the large projects under its administration, erosion and siltation problems have been somewhat alleviated. Regulations are not as strictly enforced against government agencies or private operations as against construction firms. This is because environmental health workers are put in the awkward position of bringing charges against their own government, neighbors, or kin. Especially when budgets are stretched, the philosophy that "environmental protection is fine as long as it doesn't impede progress" prevails.

The problem of local enforcement would be made easier if public support existed for the enforcement of land use regulations. In Micronesia, the public is only now beginning to become aware of siltation problems. This limited awareness, combined with a natural hesitancy to complain, especially when otherwise desirable projects are underway, makes the work of local enforcers of environmental regulations difficult.

The omission of agricultural activities from earthmoving permit requirements is a cause for concern. Traditional subsistence agricultural practices such as taro patch culture and cyclical forest gardening, where the canopy is gradually removed and later allowed to grow back, conserve soil resources. But newer practices, such as the burning of large areas, farming on steep slopes, and clearing with bulldozers, result in site degradation and increased soil erosion.

The TTPI Five Year Indicative Development Plan places priority on agricultural development, and there is a tendency for neoagricultural projects to be preceded by the clearing of large areas with bulldozers, leaving the soil easily degraded and eroded.

However, the more classical agroforestry system once prevented soil losses; now this system has been reduced or eliminated on many islands due to food programs and other alternatives. The necessary skills and knowledge are being lost and may only reside in the hands of the oldest generation. The Forest Service, U.S.D.A., is currently beginning a project to evaluate traditional agroforestry in Micronesia. Agroforests consist largely of multiple use food trees and represent a well adapted system of "permanent agriculture" (Douglas and Hart 1968). The current vegetation mapping project of the TTPI by the Forest Service has demarcated considerable acreage devoted to this traditional agricultural specialty. It is a most effective system of land use, especially on slopes where openland bare soil type of agriculture would otherwise result in erosion and subsequent siltation.

There is also need to define and protect watershed areas in Micronesia, and to control wildfires so that soils will not continue to be degraded, and nutrients lost to erosion.

The building of roads and causeways is a major source of siltation, both directly and indirectly. These roads are generally made of coral fill, which is often obtained through dredging operations. Also, new roads often provide access to forested slopes, where soils are more fertile than those degraded by repeated burning. Without regulatory controls on earthmoving for agricultural purposes on sloping land, the tree cover is destroyed and erosion generally follows.

Another serious problem is that many roads are being built along the perimeter of high islands, either between the land and mangrove, or through the mangrove forests. Unlike old paths in such areas, which had many passages for water and bridges, these roads are created with heavy machinery so that the soil is compacted. Bridges and culverts, being expensive, are built only where necessary to meet engineering requirements. There is a need to evaluate the impact of these roads on nutrient cycling between land and sea. The contribution of nutrient-rich runoff from the land to mangroves, and the function of mangroves in settling sediments and regulating nutrient flow to the lagoon, is becoming well known. In a number of instances, tidal water flows to mangroves have been cut off, causing the mangrove trees to die. The effect on mangroves can be seen, whereas the effect on seagrass communities and lagoon and reef communities beyond is not yet apparent. If we consider the mangrove as a physical and biochemical filter, then the situation is analogous to clogging the pores of the filter and punching a few big holes. Major roadbuilding projects are now being carried out on many high islands and there are no provisions for environmental impact assessment and no appraisals of the damage being done.

Oil Spills

There have been many oil spills, mostly small, in Micronesia. Their most spectacular effect has been the death of mangrove trees. The effects on corals have not been assessed. These spills were lamented and "prohibited" by local legislation, but little action was taken until about 1973, in response to the U.S. Federal Water Quality Act of 1970. In 1974, 18 oil spill reports were submitted from Yap alone. One of these reports was against a private firm, three against the local Department of Public Works power plant, five against TTPI Government field trip ships, and six against the U.S. Coast Guard LORAN station installation. The source of the remaining spills was not legally determined. The most striking effect of these and other oil spills is the dieback of mangrove trees.

V. APPROPRIATE OBJECTIVES OF CONGRESSIONAL ACTION

There has recently been a growing awareness, in the American Pacific societies, of the importance of the forest resources to the future economic growth of the islands. There is also an increasing recognition of the need for managed forests, forests that can provide fiber, food, and water while protecting the lands from erosion. Unfortunately, the measures taken to date to establish good forestry and related conservation practices have been inadequate. Immediate steps must be taken to assure that the existing forest resources are managed and improved within a framework of land-use planning. Despite the fact that forestry programs are long-term by nature, there are important actions that can provide important pay-offs to society within 5 years, or less. Existing technologies can be applied for many of these actions with few modifications. Pacific Islands forestry research promises fast answers—benefiting from year-round growing seasons and from related studies conducted elsewhere throughout the tropics and sub-tropics.

There is a need to renew and strengthen a "Conservation Ethic" in the American Pacific peoples, just as there is elsewhere in the world. Programs are needed to demonstrate the principals of conservation; provide for protection to the natural resources through the passage of wise land-use laws and policies, and for their enforcement. Conservation-education in the schools should be intensified.

Support must be provided to strengthen and improve the existing forestry/conservation departments and their programs. Additional training is needed for many of the foresters, conservationists, and technicians. Advanced education at the college level is also needed, one reason being to give foresters a working status equal to their counterparts in agriculture. The Intra-agency Personnel Act (IPA) provides an avenue for the movement of professionals from Federal agencies to agencies in need of assistance. Funds should be provided to cover the costs of 2-year or longer assignments, as a stop gap measure to provide immediate assistance.

There is a lack of specific forest management guidelines for decision making on the tropical islands. Land managers and foresters need information, which must come from research investigations. A major objective of Congressional action should be to support research and development programs potentially able to produce the technologies essential to sustain the tropical Pacific Islands forest resources. Such programs should, for example, consider the model island concept for both the high islands and the atolls, silvicultural prescriptions for natural and man-made forests, and improved utilization technologies.

These and related actions are grouped, in the next section, within three broad categories encompassing measures to:

1. Stop resource deterioration.

2. Improve forest resources.

3. Sustain forest resources.

VI. ACTIONS TO ACCOMPLISH FORESTRY OBJECTIVES

The appropriate measures which must be taken in order to accomplish the Congressional objectives listed in the previous section are:

A. Measures to Stop Resource Deterioration
B. Measures to Improve Forest Resources
C. Measures to Sustain Forest Resources

A. Measures to Stop Resource Deterioration

1. Preservation and protection of primary forest and woodlands:

   (a) Identify and delineate public (government) lands and assign protection and management responsibilities to the resource agency.

   Lead Agencies: U.S. Forest Service, U.S. Fish and Wildlife Service, Island Governments
   Supporting Agencies: Universities, Non-profit Organizations

   (b) Strengthen, and where lacking create, effective natural resource conservation enforcement agencies having a dual role of participating in conservation education.

   Lead Agencies: Island Governments
   Supporting Agencies: U.S. Forest Service

   (c) Prepare Environmental Impact Statements (EIS), plus public hearings, and approval by the resource agency, to control and monitor logging, land clearing, road construction, coral mining etc.

   Lead Agencies: Island Governments, Army Corps of Engineers, OICC - U.S. Navy, U.S. Fish and Wildlife Service.

   (d) Develop or improve existing fire suppression capabilities supplemented by trained, local volunteers.

   Lead Agencies: U.S. Forest Service, Island Governments, Military (where present)

   (e) Promote the concept of natural areas, with participation in the identification of such areas, their establishment, protection, and use.

   Lead Agencies: U.S. Forest Service, U.S. Fish and Wildlife Service, National Park Service, Island Governments, Universities, and Non-profit organizations.

2. Stabilization Schemes

(a) Restrict the use of eroding lands for military or recreational purposes, until such sites are stabilized through the establishment of vigorous vegetative cover.

Lead Agencies: Island Governments, Military, U.S. Forest Service

(b) Identify practices for successfully establishing fuelbreak plantings on the grasslands and savannal vegetation cover types in the Marianna Islands, Truk, Yap, and Palau.

Lead Agencies: U.S. Forest Service, Soil Conservation Service, Island Governments
Supporting Agencies: Universities

(c) Introduce new shrub and tree species, and develop cultural practices to reforest degraded lands, thereby preventing soil losses and siltation, and eventually improving site conditions.

Lead Agencies: U.S. Forest Service, Soil Conservation Service, Island Governments
Supporting Agencies: Universities, Peace Corps

(d) Identify those mangrove areas that are dying or are understocked due to mistreatment, and attempt through research, to rehabilitate these stands.

Lead Agencies: U.S. Forest Service, Island Governments
Supporting Agencies: Peace Corps, East/West Center, South Pacific Commission

B. Measures to Improve Forest Resources

1. Inventory the primary forests and woodland resources.[5]

(a) Conduct vegetation mapping and forest land assessments in the Territories of Guam and American Samoa, the Commonwealth of the Northern Mariana Islands, and the Republic of Palau.[6] (These measures are underway in the Federated States of Micronesia, in Cooperation with the U.S. Forest Service.)

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[5] A forest assessment of the Federated States of Micronesia has been funded by that government, and will be completed by the Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture, in 1983.

[6] The field work for the vegetation mapping of Palau, Yap, Truk, Panape, and Kosrae, funded by the T.T.P.I. and the Forest Service, has been completed. Reports will be published by the Pacific Southwest Forest and Range Experiment Station., Forest Service, U.S. Department of Agriculture, in 1983.

Lead Agencies: U.S. Forest Service, U.S. Fish and Wildlife Service, Soil Conservation Service, Hawaii Division of Forestry and Wildlife, Universities, Island Governments, Army Corps of Engineers
Supporting Agencies: Island Governments

(b) Determine growth and yields of both native and man-made forests, through the establishment and maintenance of permanent growth plots and periodic measurements.

Lead Agencies: U.S. Forest Service, Island Governments
Supporting Agencies: Hawaii Division of Forestry and Wildlife

(c) Conduct surveys of island flora and fauna, emphasizing the current status of threatened and endangered species.

Lead Agencies: U.S. Fish and Wildlife Service, U.S. Forest Service, Island Governments, Universities, and private organizations
Supportng Agencies: Peace Corps, National Park Service

2. Inventory Traditional Knowledge

(a) Conduct surveys of subsistence agriculture technologies to determine current productivity levels.

Lead Agencies: Island Governments, U.S. Forest Service, Universities

(b) Seek out knowledge of "island" medical treatments and medical plants used by native herbalists, and evaluate these plants and their properties, for use in modern medicine.

Lead Agencies: East/West Center, Universities, Contractors
Supporting Agencies: U.S. Forest Service, Peace Corps, Non-profit organiations

3. Technology Transfer

(a) Establish forestry and agro-forestry demonstration areas to help describe resource management techniques and potentials to land managers and local government officials.

Lead Agencies: U.S. Forest Service, Soil Conservation Service
Supporting Agencies: Island Governments, Peace Corps

(b) Provide island foresters, land managers, and private owners with guidelines presented in the form of well written manuals, and where useful, in the local language.

Lead Agencies: U.S. Forest Service, Peace Corps, Universities, East/West Center
Supporting Agencies: Island Governments

4. Increase production from primary forests without interfering with their sustainability and improve the use of converted lands.

   (a) Acquire data on the land base, i.e., soil, topography, weather, site conditons, past use, etc., needed to identify land use alternatives; also identify and present to land use planners the best alternatives generated from computer models.

   Lead Agencies: U.S. Forest Service, Soil Conservation Service, Island Governments, Universities, Non-profit organizations

   (b) Generate silviculture research data from experiments in the American Pacific islands and related, advanced technologies from other tropical countries . . . including establishment and development practices (i.e., fertilizer trials, spacing, rotation age), growth and yields, tree improvement, and harvesting practices for both natural and non-native species.

   Lead Agencies: U.S. Forest Service, Peace Corps, Island Governments
   Supporting Agencies: East/West Center

   (c) Develop new technologies in agro-forestry that will substantially increase the productivity of lands currently farmed practicing traditional agricultural methods.

   Lead Agencies: U.S. Forest Service, Agricultural Research Service
   Supporting Agencies: Island Governments, Soil Conservation Service, Universities, Peace Corps

   (d) Establish experimental fuel wood plantations as the initial step in developing a renewable source of biomass for energy.

   Lead Agencies: U.S. Forest Service, Island Governments
   Supporting Agencies: Universities, Peace Corps

   (e) Develop technoligies to utilize stemwood of senescent coconut trees.

   Lead Agencies: Island Governments, U.S. Forest Service

5. Increase use-efficiency of tropical products.[7]

   (a) Identify the sivical characteristics and the various uses of the tree species occurring throughout the Pacific and disseminate this knowledge to increase the versatility of various species.

      Lead Agencies: U.S. Forest Service, South Pacific Commission
      Supportng Agencies: AID Cooperators, Island Governments, East/West Center

2. Determine the wood characteristics of the native species used for construction and fuelwood.

      Lead Agency: U.S. Forest Service
      Supporting Agencies: Island Governments, Peace Corps

C. Measures to Sustain Tropical Forests Resources

1. Instill resource-valuing attitudes

   (a) Intensify conservation education programs for the public, emphasizing where practical, the old and perhaps nearly forgotten traditional concepts of resource conservation.

      Lead Agencies: U.S. Forest Service, Island Goverments, Universities, Peace Corps, Non-profit Organizations

   (b) Identify and utilize local island conservation-education specialists to prepare publications and T.V. programs that contain local flavor and approach.

      Lead Agencies: U.S. Forest Service, Universities, South Pacific Commission
      Supporting Agencies: Island Governments, Peace Corps, Non-profit Organizations

2. Increase and improve technical training and education.

   (a) Identify and support the educational facility in the mid-Pacific which can best provide forestry/conservation training at both ranger school and college levels, and provide financial assistance to promising students.

      Lead Agencies: East/West Center, Universities, Island Governments

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[7] The concept of complete tree utilization (using leaves, branches, roots, and stem) is considered very suspect, as the nutrients in tropical forests are largely held in the trees, with very little in the soil.

Supporting Agencies: Agency for International Development (AID), U.S. Forest Service, Soil Conservation Service, Private Foundations, World Bank

(b) Provide short-course programs in all aspects of forestry and forestry-related subjects.

Lead Agencies: U.S. Forest Service, East/West Center, Universities, South Pacific Commission
Supporting Agenices: Island Governments, Peace Corps

3. Increase quality of information about tropical forest ecosystems.

Lead Agencies: U.S. Forest Service, South Pacific Commission, East/West Center, Universities
Supporting Agencies: Island Governments

4. Increase availability of existing knowledge of tropical forests.

(a) Improve and expand the information network of the existing centers (for example, the Forest Service's Pacific Islands Forestry Information Center - PACIFICA; Mariana Area Research Center - MARC; and the University of Hawaii Information Center).

Lead Agencies: U.S. Forest Service, Universities
Supporting Agencies: Island Governments, Peace Corps, Aagency for International Development, Non-profit Organizations

(b) Create a Corps of local, grass roots naturalists (i.e., bare-foot or para-naturalists), providing them with generalized training that would qualify them to assist both permanently assigned and visiting scientists conduct their work, and help integrate new technologies with local customs, thereby permitting a neo-traditional environmental ethic to emerge and flourish in the Pacific Basin.

Lead Agencies: U.S. Forest Service, Island Governmnets, Universities

VII. IMPLEMENTATION OF PROPOSED ACTIVITIES

The social, economic, political and environmental impact of this program is positive and highly significant in relation to existing conditions, trends, and potentials. Developing the knowledge and eventual implementation of forest resource management programs will benefit western Pacific peoples in many ways. These people will regain incentives to provide food and fiber for themselves as current welfare programs decrease and resources become more available. Agro-forestry, with its potential of including modern high yield varieties and cultural methods, can become a major source of food as it was in the past. If the people can become more self-sufficient, these economies will stabilize and they will become more resistant to resource development by outsiders. The proposed improvement in forest resources would increase water supplies, decrease marine siltation, provide wood products and fuel, and protect wildlife and scenery. This program, if initiated in the near future will help prevent criticism by world powers about U.S. management of the TTPI.

The goal of this program should be to complete priority research in 10 years, begin increased technology transfer activities immediately, and implement operational programs during the 10 year period. The following timeframes are only estimates. They could be refined if more information on funding, lead agencies, cooperative agreements and personnel were made available. From operational program initiation until the first quantifiable results would be as follows if adequate support were available.

	Years
. Stabilization Projects (installed)	1
. Resource assessment and surveys (completed)	1-3
. Resource Information System (Expand PACIFICA)	1
. Improved coconuts (planted)	2-5
. Education programs (implemented)	3
. Fuel wood plantations (producing)	5
. Improved Agro-forestry systems (producing)	5
. Timber products (significant production)	25

VIII. CONGRESSIONAL ACTIONS NEEDED

There is no new legislation required to implement an effective forest resource research and operational program in the Western Pacific Islands. The key federal agencies required to make such a program successful are adequately chartered for such an expanded mission. The following actions by Congress would insure program goals.

- Appropriation of funds for lead agencies, organization, universities and contractors.
- Provision of funds for cooperative activities with Island Governments. (matching?)
- Determine the relationship between these programs and the Free-Association Agreements, defining future federal assistance and roles in natural resource management.
- Determine the opportunities for using funds described in the Free-Association Agreements for forest resource programs.
- Determine the possibility for involvement of International Programs such as U.S. Agency for International Development in the Western Pacific Islands.

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Appendix No. ________

List of Agencies and Institutes in the American Pacific

A. Federal

- U.S. Department of Agriculture--Forest Service
  - Pacific Southwest Forest and Range Experiment Station
  - Pacific Northwest Forest and Range Experiment Station
  - Region 5
  - State & Private Forestry
- U.S. Department of Agriculture--Soil Conservation
- U.S. Department of Agriculture--Agriculture Research Service
- U.S. Department of Interior--Fish and Wildlife Service
- U.S. Department of Interior--National Park Service
- Army Corps of Engineer, DOD
- ACTION (Peace Corps)
- East-West Center

B. State

- Hawaii Department of Land and Natural Resources

C. Universities and Colleges

- American Samoa Community College
- College of Micronesia
- University of Guam
- University of Hawaii

D. Island Governments

- Territory of American Samoa
  - Department of Agriculture
- Territory of Guam
  - Department of Agriculture

Bureau of Planning

Commonwealth of Northern Mariana Islands

Department of Natural Resources

Republic of the Marshall Islands

Department of Resources & Development

Republic of Palau

Department of National Resources

Federated States of Micronesia

Kosrae State, Dept. of Resources and Development

Ponape State, " " " " "

Truk State, " " " " "

Yap State, " " " " "

Non-profit Organizations

Natural Resources Defense Council, Inc.

Sierra Club

Background Paper No 4

FORESTRY AND AGROFORESTRY TECHNOLOGIES:
DEVELOPMENT POTENTIALS IN U.S.-AFFILIATED CARIBBEAN ISLANDS

by

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ABSTRACT

Technologies for agroforestry are well known even if not presently practised as in the past. The social constraints and economic policies limit the increased application of agroforestry production systems in the U.S. Car-bbean, since income derived from part-time labor and food stamps is preferrable to income generated from long-term tree crop rotations.

There are an estimated 20,000 farmers and an area of 750,000 acres which are appropriate for agroforestry production schemes in Puerto Rico. In the U.S. Virgin Islands there are an estimated 20,000 acres for permanent tree crops or forest species , but less than 200 farmers both full and part-time. The impact of improving the agroforestry practices will not only contribute to the long-term conservation of soil, water and forest resources, but will also concentrate the production of food, fiber, forage, and forest products in a smaller area sparing fragile lands which yield less and are easily susceptible to resource degradation.

Land abandonment rather than conflict in land use is probably one of the most significant causes of unproductive land use. The abandoned land is not necessarily unproductive in terms of soil fertility or limiting physical properties which will not support food or tree crops, but rather the lands cost too much to manage. Natural second-growth regeneration that accompanies land abandonment is increasing although there is no definitive vision from the public or private sector as to the sustainable future use of these lands.

Puerto Rico should be designated to develop a comprehensive research effort in agroforestry where all existing knowledge and experience is synthesized for the U.S. Caribbean and Tropical America. One Federal agency should be given the responsibility to coordinate and direct agroforestry research and implementation programs for local as well as international donor agencies. An immediate review of all Federal funding should be evaluated in order to improve the use of funds already available.

Despite the social and political differences, the ecological conditions of the U.S. Caribbean are similar to other tropical areas where rural populations depend heavily on natural resources. Misue and destruction of these resources is reducing the human carrying capacity of these fragile ecosystems.

INTRODUCTION

CONCEPT

Agroforestry is a popular name for an old concept. Agroforestry includes planting rees in a watershed, nest to the house, or on agricultural lands. There are two uses of trees grown in connection with food crops: (1) trees that are intetrated horizontally with food crops, beside or around them, but do not impact the food crop (i.e. live tree fences, windbreaks, etc.); and (2) trees that are integrated vertically through nutrient cycling, shade, reduced need to fallow, which commonly produce perennial cash crops (e.g., pasture/coconuts, coffee/shade). Agroforestry schemes do not substitute for intensive agriculture, but rather should be viewed as one method to maintain slopes in permanent production and to rehabilitate previously deforested lands (Weaver, 1979).

POTENTIAL BENEFITS OF AGROFORESTRY

In the humid mountain region of Puerto Rico there are an estimated 20,000 farmers and an estimated area of 750,000 acres including tree crop plantings, (coffee, citrus, plantains, bananas), pastures, abandoned fallows, and natural second-growth forest which are appropriate for agroforestry production schemes (Vincente-Chandler, 1978). The potential area is classified in the ecological life zone system as subtropical moist (annual precipitation 1,000-2,000 mm) and subtropical wet (annual precipitation greater than 2,000 mm) and suitable for permanent tree crops or productive forest plantations (Ewel and Whitmore, 1973) (Table 1). Utilizing the land capability classification of the USDA Soil Conservation Service, the soil resources of these areas include deep soils with less than 50% slope (485,312 acres) and medium deep soils with slopes greater than 50% (280,462 acres). Even though the soils have been classified for potential uses and the actual land use quantified (Department of Natural Resources ,1973), a detailed study of the potential agroforestry area has not been attempted. Improving agroforestry practices will not only contribute to the long-term conservation of soil, water and forest resources, but will also concentrate the production of food, fiber, forage and forest products in a smaller area sparing fragile lands which yield less and are easily susceptible to resource degradation.

In the U.S. Virgin Islands, ther are an estimated 34,000 acres classified in the woodland suitability group (conditions characterized by potential wood and crop productivity, management requirements, and soil limitations) of which approximately 20,000 acres have potential for permanent tree crops and/or species for wood or fuel production (USDA, 1970). Currently this land is abandoned or used as extensive poor quality grazing area. A large percentage of this area is classified as subtropical dry forest wihc suggest that any agroforestry scheme should be adapted to that dry climate (annual precipitation 500-1,000 mm) and soil conditions. Of the estimated 200 farmers (full and part-time), an estimated 50 might be interested in implementing new or strengthening existing agroforestry production technologies (Dr. Darshan S. Padda, personal communication).

Agricultural enterprises with intensive labor such as agroforestry have a far greater impact on the economy of the U.S. Caribbean islands than do those operations whose costs are mainly for materials. In Puerto Rico it is estimated that every dollar in farm wages has a multiplier effect of 1.3 on the island's gross product; an impact greater than the industrial, tourism, or construction dollar. Each job in agriculture indirectly creates an opportunity for two other jobs in other sectors of the economy

(Vincente-Chandler, 1978).

Besides the obvious soci-economic benefites to the rural interior of Puerto Rico and the U.S. Virgin Islands, agroforestry technologies contribute significantly to the sound environmental management of natural resources. Beneficial environmental services include clean water supply, erosion and flood control, reduction of stream sedimentation and provision of recreation and wildlife habitat (Schmidt, 1982).

AGROFORESTRY TECHNOLOGIES

HISTORICAL BACKGROUND

Previous to the Spanish colonization, the Indians produced their food crops by shifting cultivation or "conuco" methods since unused forest lands were readily available to rotate crops and forest fallow. Subsequently, more than 150 years ago Spanish settler began clearing areas of virgin forest for shade coffee (Murphy, 1916). Cacao was also planted with shade. The objective of the cacao planting was to restore forest cover which was desirable because it serves as a bird habitat necessary for insect pest control as well as providing an agricultural crop (Murphy, 1916).

Another non-traditional crop that is neither food nor forestry that was planted on slopes too steep for cultivation of other economic crops was by rum (*Pimenta racemosa*). The oil is used for its pleasant smelling perfume and healing qualities. In Cabo Rojo, bay trees were planted in rolling pastures as borders between fields and used for fence posts as well as shade for livestoc The economic importance of bay rum reached its peak during the

1930's when practically the entire world's supply of bay oil was produced in the West Indies, primarily in Puerto Rico and St. John's (Childers, et al., 1948). Today only 180 acres remains near Adjuntas, Puerto Rico where oil is sold for healing lotions and the leaf and twig debris is sols as a compost for home gardeners.

PUERTO RICO AGROFORESTRY

Puerto Rico's coffee forests can be categorized as an intermediate agroforestry system (OTA, 1984) characterized by small to medium-sized land holdings, relatively fertile soils, and good communication and market infrastructure.

The coffee forest production system was probably the start of modern agroforestry practices in Puerto Rico (Figure 1). The comparative success of shade-grown coffee as a permanent crop stems from the similarity of its ecology to that of the natural forest which it has replaced. The shading system has apparently been in continuous use on the island since coffee was first introduced by French refugees from Haiti in 1736 (Gulick, 1952 as cited in Tosi, 1959). The first plantings were made in firgin forest which had been heavily thinned, the larger timbers of good quality being cut and sawn on the spot for use in construction of farm buildings and coffee-processing equipment. For economic rather than ecological reasons this is by far the most efficient and inexpensive of coffee planting techniques and preferred to the clearing, burning and total replanting system.

By employing natural shade in the coffee establishment phase, a smooth and non-disruptive transition was effected between two ecologically related plant communities. Underclearing and top-thinning of the natural forest would have left a sufficient number of even-spaced trees to have maintained the understory and soil micro-climate, litter and decomposing organic matter layers, moisture retention and soil structure and micro-flora close to levels found in the natural forest. Nutrients in the slashed material would have been released slowly from incorporated humus, being absorbed by the surface root systems. Recent research results have shown that forest lands converted to agriculture, particularly intensive crop cultivation for many decades results in a three-fold decrease in soil carbon (Brown and Scheffel, 1985). However, the rate of recovery of soil carbon through forest succession appears to occur within about 50-60 years in the U.S. Caribbean subtropical moist life zone.

Since the floristically complex natural shade presented a variety of special problems to sustained management, it was replaced by simpler stands of selected trees, mostly in the leguminous genera Inga and Erythrina. These fast-growing species provide uniform shade from widely-branched, platform topped crowns (Tosi, 1959). Although the wood is of poor quality, annual thinning and pruning after coffee harvest produced large quantities of firewood used in coffee drying or in the preparation of charcoal. In 1949, charcoal prepared from annual shade tree prunings had a value over $3.0 million and accounted for over half of the total charcoal produced on the island (as cited in Stella and Olivier, 1954). Shade management in the past was sometimes as much a result of high charcoal prices as an ecological requiremtn for sustained coffee production.

Wadsworth (1945) described the similarities of coffee shade and forest production as intensive regeneration and silvicultural practices. The coffee shade is managed so that at least two age classes exist and older trees are continually replaced. Pruning and thinning of coffee shade to maintain proper density is similar to selective cutting of forests. In forest management the quality trees are favored by the rmoval of the less desirable individuals which are competing for moisture, nutrients, and sunlight.

In contrast, wood production in shade coffee can never approach that obtained from a timber forest. The ideal coffee shade tree is short with a spreading umbrella-like crown providing unifome shade density over a large area. In comparison, timber trees have a straight bole and small dense crown. In order to obtain maximum production, timber trees are spaced as closely together as possible, whereas coffee shade trees are spaced as far apart as possible without breaking the continuous canopy leaving the maximum area to plant coffee.

Tosi (1959) sampled several coffee plantings in western Puerto Rico and reported 29 shade tree individuals, 20 fruit tree individuals, and 12 valuable timber species per acer (Table 2).

Until the late 1960s, shade was considered essential to coffee production (Vicente-Chandler, 1968). Twently-five years after research had deomonstrated improved yields and net income, intensive coffee plantings are grown without shade and fertilized. The shade coffee that is being abandoned is not a large economic loss to the island since low yields on large areas proved unprofitable given the high costs of harvest labor. High plant populations (1,000 trees per acre) and heavy fertilization produce yields of sun-grown coffee 5 to 7 times grater than shade coffee (Table 3). If the goals of the Department of Agriculture are reached, the coffee acreage will be reduced to 30,000 acres of intensively managed sun coffee and as a result leave an additional 100,000 acres that was formerly managed as shade coffee abandoned or available for alternative uses (Vicente-Chandler, 1978).

It is estimated that it takes 20-30 years from the time abandoned pastures or cultivated lands are invaded by successional forest species until the stand reaches large pole size (Tois, 1959) and probably 30-40 years or more until valuable timber species could be harvested. Areas of natural reforestation such as the abandoned shade coffee forests have a high potential value for immediate sustained-yield management. However, the impact of the Department of Natural Resources forestry program has had more success in reforestation and enrichment plantings of existing stands than in timber stand improvement activities (e.g. thinning, pruning and selective cutting). The lack of farmer clients who are unwilling to wait 25-50 years to realize economic returns is the factor that determines the success of timber stand improvement and forestry extension. Department of Natural Resources gives trees to interested farmers and also provides technical assistance for tree planting and maintenance.

Coffee farmers more than any other group would appreciate and probably adopt the practices of sustained-yield management since they already are experienced in managing tree stands whether it be fruit trees or coffee. However, if that potential is ever to be realized, it would be necessary to demonstrate that the periodic annual net income would be higher from forest management than land uses such as pasture or idle land.

Other agroforestry technologies that are practiced in Puerto Rico include coconuts/pasture in coastal regions, mangoes /papaya, plantains and bananas intercropped with root crops, and citron production. High density plantings of bananas and plantains (700-1,000 plants per acre) are now commonly practiced in the interior as well as in irrigated coastal lands. Another untapped resource is the wild or abandoned fruit trees (tamarind, guava, sour sop, may apple, avocados, nisperos etc.) that are found island-wide.

PAST ATTEMPTS TO ORGANIZE AGROFORESTRY

In the late 1930s the Puerto Rican and Federal governments developed the rehabilitation-in-place program (locally known as the parcelero system) in an attempt to settle families on public forest lands. Based on the principles of the taungya system of shifting cultivation, the idea was to provide landless farmers and farmers living within public forest lands small parcels on which to grow subsistence crops, harvest firewood, charcoal and forest products in exchange for planting and caring for the public forest lands (Hadley. 1940). While the parcelero cultivated food crops between tree plantings for a period of 4-5 years, forest plantations could be established at limited costs.

In a survey conducted by the Puerto Rico Agricultural Experiment Station (1941), a large percentage of parceleros earned a net farm and off-farm income lower than surrounding agricultural laborers. The lands designated for this system produced low yields and consequently low incomes. The income from forest exploitation is also low per unit of land, so an unmanageably large parcel would bave to be assigned to each farmer in order to provide for a set minimum inocme or an income comparable to similar agricultural activities. As a result of critical evaluations, the rotation of subsistence crops and forest tree planting/harvest was discontinued primarily due to low yielding agricultural/ forestry sites. As the same time more attention was given to higher qualilty sites which in practical terms means higher crop and forestry yields that will generate an adequate source of income.

Today the social situation has changed significantly in the rural interior where large numbers of the population have migrated to urban centers or off-island. The abandoned areas are now characterized as 25 to 30 year-old second-growth stands (Schmidt, 1982). The remaining population is employed as seasonal labor for coffee harvest and supplement their incomes with food stamps and occasional part-time jobs. The "old-timers" who managed the "food forests" have rapidly disappeared and the resident younger generation is usually unskilled labor who have little patience for long-term rotations (Dr. Jose Vicente-Chandler, personal communicatio In the past the rural poor depended on cheap accessible wood for cooking, but today that demand has diminished considerably and firewood is only used occasionally. Fence posts, poles and wood for construction could be harvested, but there is little evidence of any economic importance even with the emphasis and technical support offered by the forestry program of the Department of Natural Resources.

AGROFORESTRY IN THE U.S. VIRGIN ISLANDS

With the exception of the bay rum plantations exploited in the years 1930-40 (Childers et al., 1948), agroforestry systems in the U.S. Virgin Islands have traditionally been a subsistence level of production oriented to the planting of food staples (root crops, vegetables, and fruit trees) and raising of livestock and utilizing forest species for charcoal, firewood, and construction. Most of this small-scale production destined for home consumption and roadside markets is managed by a few farm families.

There are probably less than 200 active farmers that practice any form of agriculture or forestry (Dr. Darshan S. Padda and John Matuszak, personal communication). Although it is not well documented, it has been observed that during cycles of economic depression, there is a trend for a portion of the population to return to the land resources to earn a livelihood which frequently involves agroforestry land uses. Immigrants who come to improve their standard of living and obtain U.S. citizenship are accustomed to rural lifestyles of neighboring islands and prefer working in agriculture, but since they lack lack capital and land, they earn most of their income from industrial or tourism employment (Clinton George, personal communication).

The dry climate and soils dictate the kinds of food crops that are grown in association with fruit trees or forest species. The most prevalent type of subsistence agroforestry is found in backyard gardens which typically have a mixture of perennial fruit tree crops (avocado, coconut, soursop, citrus, mango, papaya, banana, etc.) interplanted with short-term food crops (cassava, corn, sweet potatoes, okra, pigeon peas, beans, etc.).

On St. Thomas, all flat lands are now filled by sprawling urbanization leaving only steep lands for any type of agricultural development. Clearing land for agricultural development is destructi since the steep slopes prohibit ground water recharge, contributing instead to massive soil loss from all but the most carefully managed lands.

An example of a more specialized agroforestry system has been developed by the French farmers who have mastered the difficulties of permanent production on sloping soils. They grow herbs and spices (Table 4) essentially clean-tilled on narrow irrigated rock terraces along with fruit trees that serve as windbreaks and also mark field boundaries. Terraces constructed to utilize steep soils and control erosion can also be built using contour rows of closely spaced fast-growing trees (Matuszak, 1984). The tree trunks are allowed to stand as the walls with the new growth regularly cut and piled horizontally above the trunks. Soil is then slowly piled above (on top) for the gradual formation of a bench terrace. Both terracing and countours increase water infiltration and organic matter accumulation. Terraces recommended by USDA Soil Consevation Service are constructed with manual labor or bulldozer generally cutting into a slope so that water can be trapped (in dry areas). In the U.S. Caribbean terrace construction ex expensive so high value crops are required to justify the investment.

Less intensive agroforestry applications include windbreaks and hedgerows composed of food crops (pigeon peas, cassava) and forage crops (Leucaena) frequently planted around garden plots to protect vegetables from wind damage. Fruit tree orchards are protected from the wind by taller trees (Eucalyptus and Australian pine Casuarina equisetifolia) planted in combination with cashew (Anacardium occidentale) and sea grape (Coccoloba uvifera) (Dillinham, 1984). Other species used for living fences include Gliricidium sapium used for forgae and many kinks of non-traditional fruit trees (sapidilla Manilkara zapote; carambola Averrhoa carambola; mammey Mammea americana; guavaberry Myciantha floribunda).

Another specialized agroforestry system, observed on St. Croix where more lands are available for agriculture, is the extensive grazing of pasture planted with mangoes (Mangifera indicus) and tamarind (Tamarindus indica). The livestock carrying capacity is low due to the dry climate rocky soil, and lack of improved grass/legume pastures. In order to avoid damage to young fruit tree seedlings, the pasture can not be grazed until fruit trees are 3-5- years old. Poor quality mango varieties and low level of livestock management produce low levels of income from this scheme.

One of the best non-conventional opportunities for agroforestry in the U.S. Virgin Islands is the emphasis given urban forestry and landscaping using fruit and shade trees (George, 1984 and Bough, 1984). Fruit trees not only provide shade and ornamental characteristic but also provide a saleable product. Private residences, hotels, and urban green areas offer an excellent opportunity to plant fruit and shade tree combinations.

AGROFORESTRY RESEARCH AND TRAINING IN THE U.S. CARIBBEAN

Agronomists and foresters have traditionally studied production aspects of food crops and tree growth respectively. Recently, however, ther has been an effort to apply ecological principles to the design of sustained-yield agroecosystems (Hart, 1979). Although the research publications for the U.S. Caribbean include agroforestry sugjects, the self-imposed boundaries between agronomists and foreste and lack of cooperative research efforts is still obvious.

In 35 years (1937-72), the Agricultural Experiment Station, University of Puerto Rico has published some 30 articles in the Puerto Rican Journal of Agriculture on coffee culture that would be useful to agroforestry managers. In an annotated bibliography on " Forestry in Puerto Rico" that includes journal articles, these, proceedings, and reports collected from 1887-1978, there are 60 references to natural forest management and 203 references to plantation silvicultural management including agroforestry. (Mosquera and Feheley, 1984). Most of the references to farm forestry (management of coffee shade, natural forest, and charcoal production) and tree crop production were prepared in the period 1900-1940 when producing fuelwood, forest products and food crops on steep lands was more important than later period when rural migrations caused by alternative urban employment and Federal subsidies (food stamps) reduced the land-use pressure on steepland resources. The library of the Institute of Tropical Forestry, Rio Piedras is recognized among Federal agencies as well as international donor and scientific agencies as the best reference collection for applied tropical forest management in the Caribbean and Latin America.

The Caribbean Food Crops Society (CFCS) is just one of many professional organizations in which the U.S. Caribbean participates annually to discuss food production issues important to the region. From 1981-83, less than 10% of the scientific papers presented could be considered agroforestry-related even though these technologies are widely practiced in the member countries. However, the organization did recommend that research priorities should include traditional and new farming practices which will improve the yields and management of agroforestry production systems (CFCS,184).

Current agroforestry practices are more diverse and varied in neighboring non-U.S. Caribbean islands where rural population pressures result in intense use of lands that are marginal for both agriculture and forestry (Pool,1982). Efforts to improve agroforestry technologies (tree crop planting, interplanting, reforestation) have been encouraged by international donor agencies (Workshop on Caribbean Forestry--Man and the Biosphere, 1982; Workshop on Traditional Fruit Tree Crops--IICA, 1981) and the subject of eastern Caribbean (food forest) fruit tree and forestry implementati projects (Pool et al., 1981) financed by USAID and the Caribbean Agricultural Research Development Institute. Even though scientists from Puerto Rico and the U.S. Virgin Islands participate and contribute in formulating research and implementation priorities, there is a lack of information flow within the U.S. Caribbean regarding the strengthening of the agroforestry component of agricultural development. Current agroforestry research is forest species oriented in the Institute of Tropical Forestry and crop association in the College of the Virgin Islands Cooperative Extension Service.

In 1983-84, the Institute of Tropical Forestry conducted two three month long training courses for young Caribbean foresters (14 per course) on tropical forestry and environmental quality in the Caribbean. One of the subjects emphasized in these courses was agroforestry (ITF, 1985).

CONSTRAINTS AND OPPORTUNITIES

FUTURE PROSPECTS Puerto Rico

There is abundant land available in the humid interior mountains that has few other use alternatives than agroforestry. Crops are traditionally grown on the better soils and trees planted on less favorable sites. To combine both food crops and tree crops on the same parcel of land may result in lower yields of both. Given the current market potential and the high cost of labor, the cropping alternatives for the humid interior include sun-grown coffee, plantains, bananas, citrus, root crops, and to a lesser extent, specialty crops such as ornamentals, Christmas trees, citron etc. Historically, the labor force in the mountains worked for wages on coffee farms and also grew subsistence crops on small plots surrounding the family residence. As the quality of living increased, the workers have utilized the wages earned to purchase home improvements or make car or appliance payments. The small plots of subsistence crops still exist, but to a much lesser extent than 15 years ago (Dr. Jose Vincente-Chandler personal communication).

Inconsistencies of stated policies and programs, while they still exist have less consequence today as compared to 40 years ago. For instance, in the 1940s the Insular and Federal Forest Services were advocating the retirement of considerable areas of steep eroded land to forestry use, while the USDA Soil Conservation Service and the Puerto Rico Department of Agriculture were proposing the cropping and grazing activities be intensified technologically on the same lands (Tosi, 1959). In the past, forest lands occupied sites so poor that their potential productivity was limited. Forest cutting was abusive and exploitative far in excess of regrowth (Tosi, 1959). Today, since there are more lands available than ideas on how to use them, the impact of poor policy or misjudgment is diminished.

Land abandonment rather than conflict in land use is probably one of the most significant causes of unproductive land use. The current coffee producing area is an estimated 100,000 acres. The intensification of su-grown coffee could yield more coffee on 30,000 acres, leaving the difference in abandoned land. The abandoned land is not necessarily unproductive in terms of soil fertility, poor soil texture, orlimiting physical properties which will will not support food or tree crops, but rather the lands cost too much to manage. The economic yield and income abandoned land generates is less than the effort exerted to manage them due to poor site quality, absentee ownership, and lack of profitable cropping and livestock production systems (Dr. Jose Vincente-Chandler, personal communication). The decision to grow trees or permanent crops on these lands rather than pastures is determined by the problems of theft, ease of management, and labor availability. Reforestation has been successful on a small-scale (1-5 acres) on sloping lands scattered throughout the interior of Puerto Rico. However commercial forest management and harvest is just now becoming a land use option since forest rotations are rather long(30-40 years) with little income generated during the growth phase. Despite free tree seedlings and technical assistance, few land owners have actually adopted timber stand improvement or reforestation activities due to the long-term land committment required. Beef cattle production is not profitable on fertilized pastures in the humid interior region of Puerto Rico (Dr. Jose Vincente-Chandler, personal communication). The small dairies on the sloping coastal soils will eventually be forced to move to less desirable lands (steeper slopes) due to high land costs and encroaching urbanization in the coastal zone. This change will occur at a slow pace, but will influence the amount of land available for other uses in the interior.

Associated with these problems is the fact that even though rural unemployment is high (unofficial estimates of 25-30% in some municipalities), alternative employment opportunities (plumbing, carpentry, electrician, etc.), food stamps, and social security from extended families all contribute to an underground economy which in some cases can provide $2000 per month in nontaxable familty income.

FUTURE PROSPECTS --U.S.VIRGIN ISLANDS

Even though the economic development is focused on tourism-relat activities, there is a growing concern among individual farmers and agricultural professionals that agricultural land must be preserved in the U.S. Virgin Islands (John Matuszak, personal communication). Agriculture/forestry is an alternative to far less desirable uses (tourism and residencial housing) and presents a balance needed to prevent takeover activities (local politicians favor tourism over agriculture because of rapid income generation) whose long-term viability is questioned (Economic Development Guidelines, 1979).

If the social constraints to agroforestry development can be removed, then the best information available on planting combinations market potential, incentive programs available, forestry rotations, charcoal and wood products (poles, posts, boards) needs to be provided to potential users. Such an action would imply a reorientation of ag extension agents that would include agroforestry technologies adopted to specific ecological land management units. Credit would have to be made available to small farmers.

Changes in land use or just plain land abandonment has caused serious decline in total acreage devoted to agriculture. On St. Thomas, the development of public housing complexes and expansion of tourist-related facilities helped speed the transition. St. John's witnessed the development of two major changes: Caneel Bay Plantation (a resort hotel), and St. John's National Park where a majority of land is preserved. This reduces the total land available for any alternative uses. St. Croix has considerable land available despite tourism and industrial complexes.

While St. Thomas farm acreage has declined almost 80% since 1917 and St. John's by over 90%, farm acreage on St. Croix remains at 44% of what it was 60 years ago (McElroy and Tinsley, n.d.).

Briefly stated, the constraints to agroforestry in the U.S. Virgin Islands are as follows:

(1) Agriculture and forestry are not a government priority. Conflict exists between the tourist-government concentration of St. Thomas and the industrial-agricultural emphasis of St. Croix.

(2) Land availability for agroforestry schemes is limited due to high land costs ($8000-15,000 per acre) and more profitable

non-agricultural uses such as housing or hotel development.

(3) Fertilizer and pesticide inputs are available, but expensive

(4) The lack of adequate nurseries requires that fruit tree seedlings be imported from Puerto Rico or Florida, and cost to the farmers runs $10-15 each.

(5) The agricultural extension and research program is effective, but there is a lack of an integrative package (financing, planting material, market) to offer farmers.

OBJECTIVES OF CONGRESSIONAL ACTION

A Caribbean agroforestry and research and extension center needs to be developed to:

(1) Coordinate all agencies dealing with agroforestry under the umbrella of a lead agency.

(2) Establish research and extension priorities to remove constraints to implementation of agroforestry technologies.

(3) Disseminate research and extension information to the U.S. Caribbean as well as the greater Caribbean.

Puerto Rico is the logical place to develop a comprehensive research and extension program in agroforestry which includes tropical forestry and agricultural land uses. Puerto Rico, classified broadly as a subtropical ecological life zone (Ewel and Whitmore, 1973), corresponds to the premontane altitudinal belt of the American tropics. Premontane areas of Latin America are characterized as follows: (1) an area where most of the food is produced; (2) an area where most of the population is concentrated; and (3) an area where widespread misuse of natural resources is occurring.

A long-term continuous research effort needs to be supported where all existing knowledge and experience on all types of agroforestry is synthesized for practical use and implementation for tropical land use managers. The lack of adequate information such as proven establishment techniques, plant spacing, thinning and pruning practices, weeding frequency, rotation time, results in trial and error management rather than well-planned long-term sustained production technology. There are eight regional development and research intitutions dealing with various aspects of agroforestry in the eastern Caribbean (Table 5). Related research on U.S. Caribbean islands should be coordinated and shared in order to take advantage of experiences applicable to Puerto Rico and the U.S. Virgin Islands as well as other Caribbean Basin countries.

One Federal agency needs to be given the responsibility for coordinating and directing agroforestry research and activity programs in the U.S. Caribbean as well as the rest of tropical America. The Soil Conservation Service deals with hillside stabilization and erosion control; the USDA Agricultural Research Service works with permanent tree crops such as coffee, bananas, plantains, cacao, etc.; and the U.S. Forest Service Institute of Tropical Forestry conducts research on tree plantations, natural forest management, and wildlife conservation. Even though each of these agencies deals with important aspects of agroforestry research, the lack of interagency communication and the lack of one lead agency directing research efforts results in a piecemeal approach to a multi-factor problem.

An action that would produce immediate results in the research and application of agroforestry technologies is not additional funding, but improved coordination in the use of funds already available. Federal and local agencies need to evaluate current research and set priorities for the future. Any long-term research and monitoring effort should include adequate financing, professional training and follow-up.

For more efficient land use in the U.S. Caribbean, ther is a need to define and classify sloping lands which are (1) appropriate for agriculture; (2) appropriate for forestry; and (3) appropriate for both (agroforestry). Even without the known range of adaptability of food crops or forest species, use of the best sites can double current yields (Wadsworth, 1982). Long-term planning should include efficient management of coffee, fruit tree crops, speciality crops such as ornamentals or Christmas trees as well as the technical management of secondary forests to provide a portion of those agricultural and forestry products not available form areas outside the U.S. Caribbean.

There is a special need to establish a research program which focuses on tropical legume species. More than one-third of tropical forest species are legumes, but not all have rhizobia and fix nitrogen (Wadsworth, 1982). Coffe shade trees, primarily leguminous species, respond to nitrogen which suggests that nitrogen fixation may not be as good as expected (Dr. Frank H. Wadsworth, personal communication). Some trees withdraw nutrients from their leaves before leaves fall. Legumes cannot give away all their energy as well as nitrogen. The emphasis on legumes as the wonder species for agroforestry systems is probably unfounded until further investigation on other unknown tree species extension service, Department of Natural Resources, U.S.V.I. Cooperative Extension Service, Farmers Home Administration, and the agricultural credit corporation (P.R.) are convinced and committed to promoting appropriate agroforestry technologies.

APPENDIX A

UPDATE OF FORESTRY TECHNOLOGIES

One area of concern is the increasing area of abandoned land in Puerto Rico and its sustained future use. Although the technology is not new, Wadsworth (1945) summarizes a practical approach to better using those abandoned lands. In order to improve both coffee and timber production, Wadsworth recommended eliminating of marginal low-producing coffee areas and managing these lands as sustained-yield forestry. Coffee should be intensified on the better soils and the result will be improved management and yields of both coffee and forests.

The improved management practices recommended for abandoned coffee lands depends on the density and height of the vegetation cover. Clearing second-growth forests or abandoned shade coffee for planting forest trees is uneconomical and unnecessary. Where forest canopy is formed, inferior quality trees can be gradually removed allowing adequate shade to preserve forest conditions for natural regeneration. Underplanting with quality wood species will accelerate this process to improve species composition. If the tree canopy is not established then management will depend on tree species present. Stump sprouts should be allowed to reach canopy size. Thinning will control density and also yield posts, poles and stakes as an immediate product. If trees are absent or only undesirable species present, then aggressive species such as maria (Calophyllum antillanum), roble (Tabebuia spp.), or Eucalyptus should be planted in four-foot diameter clearings spaced every eight feet. Weeds should be periodically controlled at least twice a year to reduce competition to the newly-planted seedlings.

The forest management practices to improve stand composition, encourage quality timber species, and efficiently manage plantations with fast-growing species are well documented, but little is actually implemented at the farm level. Even though yield data are well known for sun and shade grown coffee, the economics of forest production derived from a second-growth stand in terms of fence posts, poles and lumber that is needed to provide farmers with an adequate level of income is not well known.

Forestry land use trends and potential reforestation and forest product utilization, particularly in Puerto Rico and the U.S. Virgin Islands, are covered by Schmidt (1982). Improving the productivity of converted forest lands which includes agroforestry is capably discussed by Wadsworth (1982).

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Table 1. Geoclimatic Regions in Puerto Rico and the Agroforestry Potential (from Schmidt, 1982).

Geoclimatic Region	Agroforestry Potential	Land Use
1. Moist-alluvial	Low	Intensive agriculture and urban development are priority over alternative land uses.
2. Moist-volcanic	High	Priority area for forestry development, natural regenerati and plantation of Caribbean pine, mahogany, teak, blue maho eucalyptus and fruit tree crops
3. Moist-limestone	High	Plantations of mahogany, teak, *Eucalyptus deglupta*, blue mahoe and fruit tree crops.
4. Moist-granodioritic	Medium	Forestry plantations (Caribbean pine) more appropriate than agriculture or low productivity pastures.
5. Moist and Wet-serpentine	Low	Shallow, impermeable, infertile soils result in slow tree growt and unprofitable agriculture. Watershed protection more important priority.
6. Wet-volcanic	High	Highest priority for agroforest emphasis. Fruit tree crops, forest species, and Christmas trees develop well in lands formerly managed as shade coffe Intensive shade-less coffee wil be concentrated on better soils

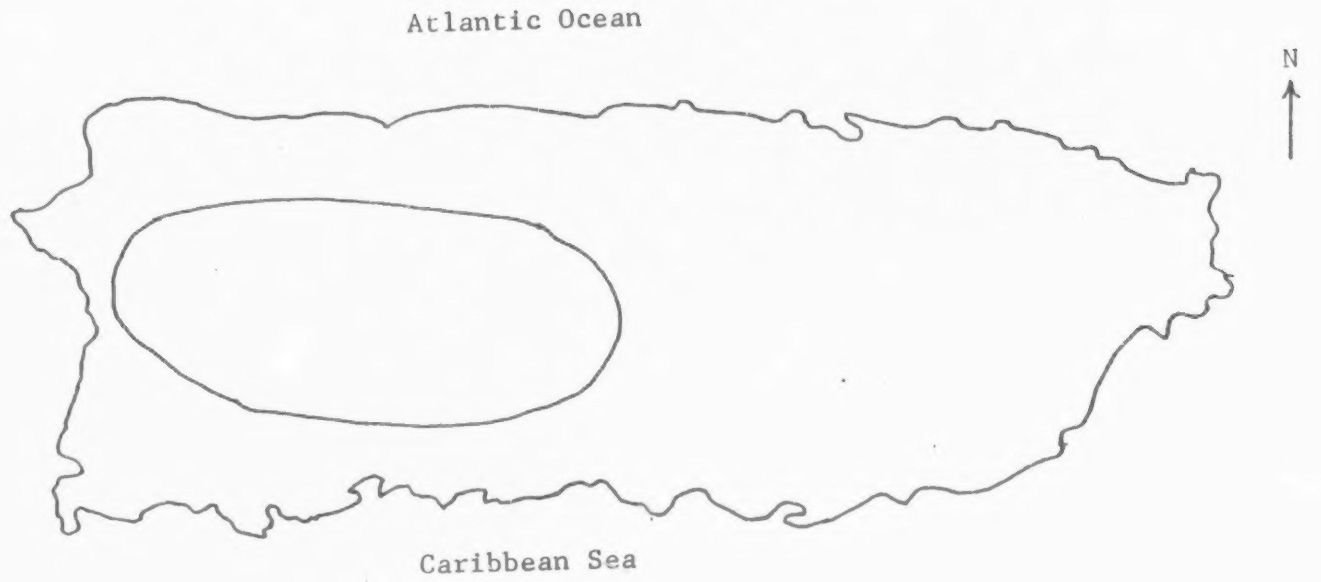

Figure 1. Agroforestry of which shade coffee is the predominant component is concentrated in an area 52 X 18 miles in the mountainous west central region of Puerto Rico. These lands range in elevation from 1000-3000 feet above sea level and are classified as subtropical moist, subtropical wet, and lower montane wet ecological life zones.

Table 2. Tree Component of Shade Coffee Grown in Puerto Rico (from Tosi, 1959)a/

Tree Strata		Trees per Acre	
		% of Total	Individuals
UPPER CANOPY			
Native Shade Species		20	29
Scientific name	Common name		
Inga laurina	guamá		
Inga vera	guava		
Erythrina spp.	bucare		
High Value Timber Species (4" DBH)b/		8	12
Guarea guarea	guaraguao		
Andira inermis	moca		
Nectandra spp.	laurel		
Cordia alliadora	capa prieto		
Cedrela odorata	cedro hembra		
Tabebuia spp.	roble		
Vitex divaricata	higuerilla		
Native/Exotic Fruit Trees		20	29
Persea persea	avocado		
Mammea americana	mammey		
Anona muricata	sour sop		
Mangifera indica	mango		
Artocarpus communis	breadfruit		
Eugenia jambos	pomarrosa		
Intercropped Fruit Trees			
Musa spp.	bananas	33	47
Citrus spp.	citrus	9	13
UNDERSTORY (1-3" DBH)		10	14
	TOTAL	100	144

---

a/ For all species except intercropped fruit trees, average tree spacing was 23 X 23 feet; average canopy height 30-40 feet; average stem diameter 7 inches DBH.

b/ DBH: Diameter at breast height or 4.5 feet above soil level.

Table 3. Comparison of Coffee Produced With and Without Shade (Gonzalez-Villafañe and Espinet Colon, 1980)

	Shade Coffee	Sun Coffee
Area in Production (acres)	100,000	10,000 [a]
Farm size(acres)	150-250	7-10
Fertilizer Use (Cwt/A)	2	20
Harvest Method	Hand	Hand and nets
Yields (Cwt/A)	less than 2	10-15

---

[a] The establishment of sun-grown coffee under intensive management is expensive and farmers receive no income for the first three years. Studies have shown that the interplanting of plantains with new coffee plantings serves as a short-term source of income generating $4160 per acre per year gross income as compared to $1800 per acre per year with sun-grown coffee only (Estacion Experimental Agricola, 1984).

Table 4. List of Herbs Grown on Bench Terraces by French Farmers on St. Thomas, U.S. Virgin Islands (John Matuszak, personal communication).

Common name	Scientific name
Rosemary	*Rosemarinus officinalis*
Marjoram	*Origanum marjorana*
Anise	*Pimpinella anisum*
Thyme	*Thymus vulgaris*
Tea bush	*Eupatorium triplinerve*
Inflammation bush	*Verbesinia alata*
Wormgrass	*Chenopodium ambrosiodes*
Basil or balsam	*Ocimum basilicum*
Sweet scent	*Ocimum sanctum*
Peppermint	*Menta* spp.
Tarragon	*Artemisia dracunculus*
Parsley	*Petroselinum crispum*
Dill	*Anethum graveolens*

Table 5. Agroforestry and Tree Crop Programs in the Caribbean (Pool, 1982).

Agency	Project	Country
British Development Division	5 year tree crop program	Dominica, St. Lucia, St. Kitts
Canadian International Development Assistance	Rehabilitation of propagation center, tree crop project	Antigua
Caribbean Agricultural Research Development Institite	Research on disease control of tree crops;	Grenada, Jamaica
	Food Forest pilot study funded by USAID	St. Lucia, Nevis
	Small farm cropping systems	English Caribbean
Caribbean Development Bank	Preparation of technical material for commercial fruit tree production	
	Establish food forest	Montserrat
Institut de Recherches sur les Fruits et Agrumes	Research on fruit tree crops	Guadeloupe,Martinique
Institute of Tropical Forestry - USDA Forest Service	Research and mgt. of natural and plantation forests for timber use, wildlife and recreation management	Puerto Rico and Tropical America
USDA-Agricultural Research Service	Tree crop research	Puerto Rico
University of Puerto Rico - Ag Exp. Station	Soil and tree crop research	Puerto Rico
Mayaguez Institute of Tropical Agriculture-USDA	Research on crops suitable for tropical areas	Puerto Rico and Tropical America
College of the Virgin Islands	Research and extension on tree crops	U.S. Virgin Islands
University of the West Indies	Research program for nontraditional fruits	English Caribbean
Windward Islands Banana Growers Assoc.	Terracing for tree crops	Grenada, St, Vincen St. Lucia, Dominica

Table 6. Agroforestry Research Priorities (Wadsworth, 1982)

- Fertilizer use and cost
- Quantitative economic and environmental analysis of each agroforestry system
- Assessment of genotypes of food, forage, and forest species
- Species tolerance to poor sites, low nutritional levels, resistence to insect pests and diseases
- Canopy density, spacing, growth form
- Species compatibility including tropical legumes and other unknown species

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PERSONS INTERVIEWED

Institute of Tropical Forestry - USDA Forest Service

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USDA - Agricultural Research Service

Dr. Jose Vicente-Chandler

Soil Conservation Service

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Department of Natural Resources

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College of the Virgin Islands

Dr. Darshan S. Padda
Dr. Walter I. Knausenberger
John Matuszak
G. Houston Holder
Clinton George
Robert Webb
Carlos Robles

Others

Oscar Henry - Former commissioner of agriculture U.S. Virgin Islands
Sue Higgins - USVI Planning Office
Lionel Jacobs - USVI Planning Office
Dr. Ed Towle - Island Resources Foundation, member OTA advisory committee
Dr. Allen Putney - Eastern Caribbean Natural Areas Management Program

Background Paper No. 5

FORESTRY: PUERTO RICO AND THE VIRGIN ISLANDS

by

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Forest Service

1982

Prepared for

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ABSTRACT

Puerto Rico and the U. S. Virgin Islands tropical forest ecosystems may be classified within the Holdridge life zone system, and are similar in structure and productivity to other tropical forests that fall into the same life zones. Economic development of the islands has increased the benefits and feasibility of commercial forestry operations. Large tracts of land suitable for commercial forestry have been abandoned to agriculture due to increased infertility and alternative economic opportunities. The Virgin Islands could develope a small crafts and furniture industry based on tropical hardwoods on a few thousand acres. Puerto Rico has at least 200,000 acres whose best use is commercial forestry Softwood and hardwood production on this land could substitute $100,000,000 of the more than $400,000,000 of forest products that were imported in 1981. 25,000 direct rural jobs would be created within 20 years, with an economic multiplier effect estimated at 5 to 10 times. Subtantial, but at present unquantifiable, benefits would be produced in erosion control, sediment reduction, regulation of water quality, quantity and regimen, wildlife habitat enhancement and opportunities for forest recreation and research. 100,000 acres are now in forest or natural reserves in Puerto Rico and protection programs are effective. However since 1,000,000 acres is judged to need tree cover, increasing benefits mentioned above through reforestation programs is important. No new institutions or programs are necessary to accomplish these goals. The U. S. Forest Service, through its State and Private Forestry Branch and the Institute of Tropical Forestry can cooperate with the Departament of Natural Resources and the Forest Service of Puerto Rico and the Forest Service of the Virgin Islands. There is no forestry or forest ecology program of higher education in the U.S. Caribbean, and this vital need requires study through the universities and the institutions mentioned above. The economic viability of forest establishment and harvesting in Puerto Rico is analyzed, and the rate of return on the investment is 19 per cent.

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FORESTRY-PUERTO RICO AND VIRGIN ISLANDS

PREFACE OR INTRODUCTION

The development of forest resources in Puerto Rico (P.R.) and the United States, Virgin Islands (U.S.V.I.) offers, at this point in time a substancial potential and challenge. Successful development of this resource requires the best possible understanding of a very complex set of interrelated conditions including biological and ecological conditions, general economics, and forest economics and political and psychological realtions within the islands and between the islands and the Federal Government. Looking back over the better part of a century, there has never been a greater rationale or possibility for success for developing sound forest management in P.R. and the U.S.V.I.

FOREST ECOSYSTEMS IN PUERTO RICO AND THE U.S. VIRGIN ISLANDS

The forests of the islands are clearly tropical, sharing many common features with the extensive tropical forests of the South and Central American continent, and yet display numerous unique ecological and historical attributes. Like most tropical forests (Richard 1952; Whitmore 1979) the island's forests are species rich in trees. The 547 native tree species found within an area of 9392 Km^2 (Little, _et al_. 1969,1974) approximates the number of tree species found in the continental United States (Little 1979).

Of these 547 species, 55 are shared with South America, and 53 with Central America (Little et al. 1974). If one excludes the extreme southern part of Florida which has tropical characteristics, less than five tree species are shared between P.R., the U.S.V.I. and the continental U.S. In Mexico, at latitudes similar to the islands, highland forests with temperate genera such as Querus, Liquidambar, Alnus, and Pinus (oak, sweetgum, alder, and pine) are present, but no such forests exist in P.R. or the U.S. V.I. The forests are tropical, and more particularly neo-tropical (tropical western hemisphere). In structure, species composition, productivity, and management potential they are very similar to forests found in South and Central America. Important differences between them will be considered below.

The ecological characterization of forest communities in P.R. and U.S.V.I. may be viewed through two classical systems. Beard (1944, 1955) closely examined forests throughout the greater Caribbean area and divided them in two different types based mainly on floristics, especially deciduousness, and species composition. He envisioned an optimum type, the rain forest, in the center of a wheel with lesser developed types aligned along the spokes of the wheel according to various limiting factors. As conditions become drier a greater percentage of deciduous species are encountered in any vegetation community. According to this percentage the forest is labeled semi-evergreen, seasonal, dry evergreen, etc. Beard was able to define climatic conditions that would give rise to these forest types based on total quantity and seasonality of rainfall. How these communities might be arranged on a typical Caribbean Island are shown in figure 2 adapted from Beard, 1949. Beard's system is very useful to researchers or managers of Caribbean forest ecosystems. Beard's knowledge of the islands forests was detailed and comprehensive; the forest types he defined can be seen clearly in the field and few gasp exist.

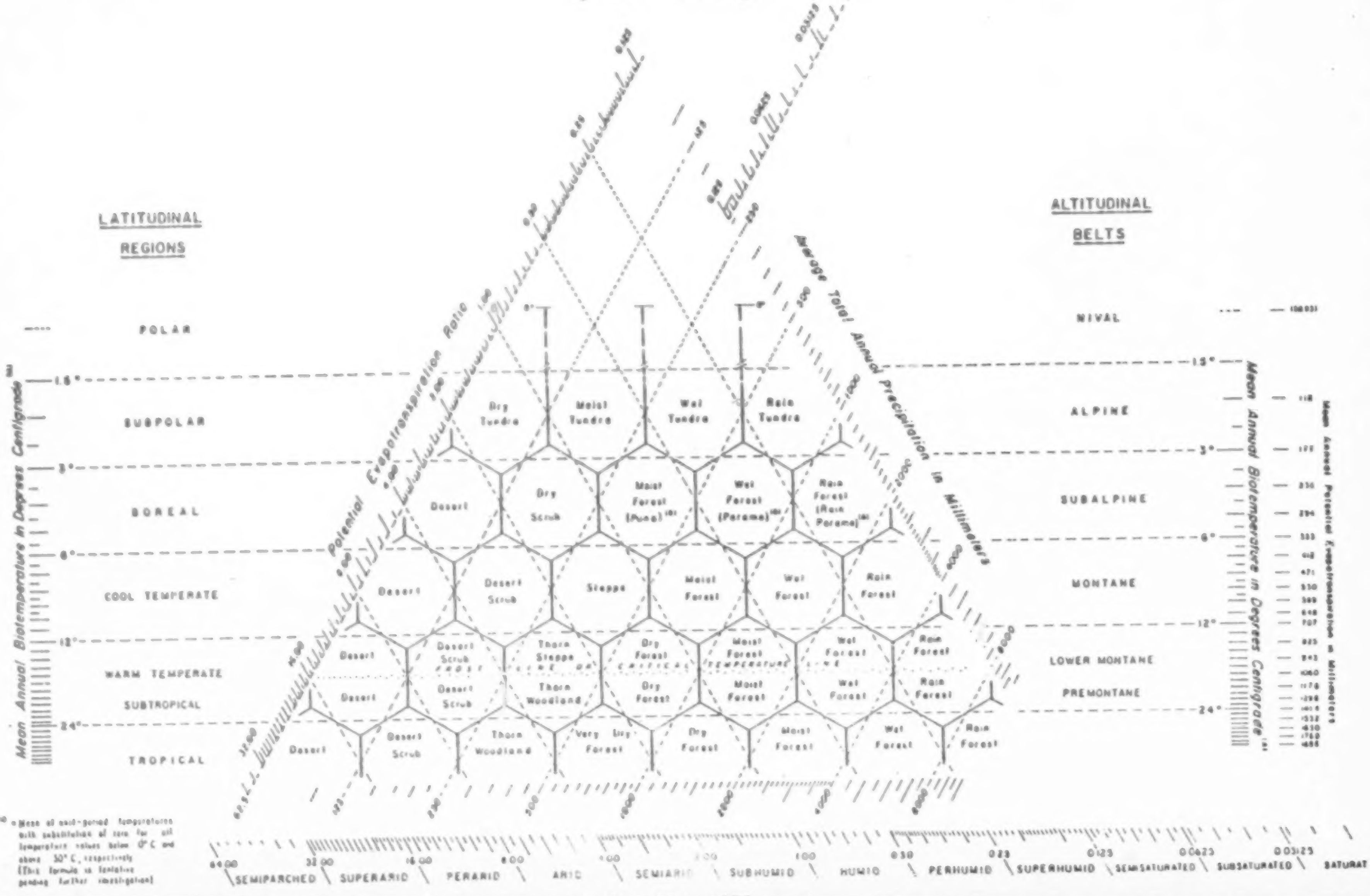
Leslie Holdridge was forester in Puerto Rico in the 1930s and 40s and has spent most of his life working with forest ecosystems in the greater Caribbean. He first published his lifezone system of classification in 1947 and has continued to refine it (Holdridge 1967, 1979). The system is graphically presented by the Holdridge triangle (Fig. 1). Ewel and Whitmore (1973) supply this description:

> " Each life zone lies within: 1) a Latitudinal Region (left side of Figure 1); 2.) an Altitudinal Belt (right side of Figure 1); and 3.) a Humidity Province (bottom Figure 1). The variables used to delineate any given life zone are mean annual precipitation and mean annual biotemperature.
>
> " Mean biotemperature is mean air temperature modified by substituting zero for values outside the range of 0 to 30C, as discussed in Appendix A. The mean biotemperature scale appears along the sides of Figure 1. The values decrease geometrically from 30 at the bottom to 1.5 C at the top. The Latitudinal Region at any given location is determined by increasing the mean biotemperature to the value it would have at sea level. For making this conversion a lapse rate of 6 C per 1000 m is commonly used; most areas of the world fall in the range of 5.5 to 6.5 C per 1000 m. The mean biotemperature not corrected for

FIG I

DIAGRAM FOR THE CLASSIFICATION OF WORLD LIFE ZONES OR PLANT FORMATIONS.

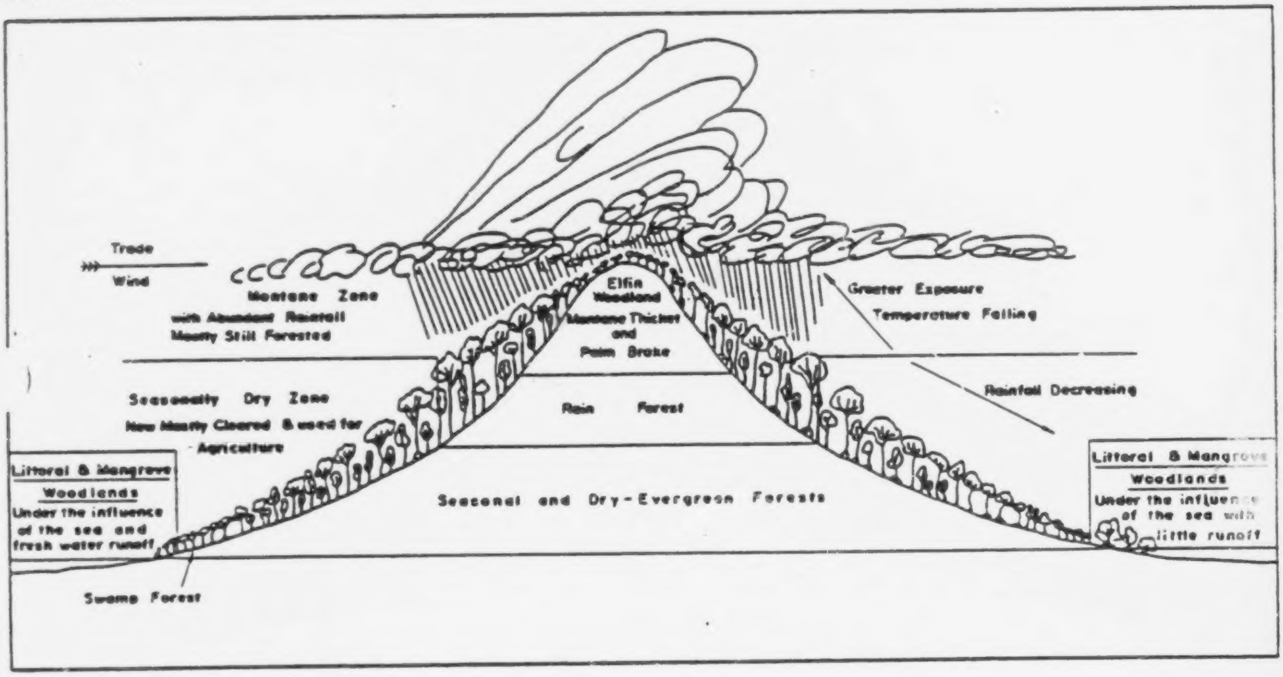
by L. R. Holdridge



LATITUDINAL REGIONS
POLAR
SUBPOLAR
BOREAL
COOL TEMPERATE
WARM TEMPERATE
SUBTROPICAL
TROPICAL
ALTITUDINAL BELTS
NIVAL
ALPINE
SUBALPINE
MONTANE
LOWER MONTANE
PREMONTANE
Mean Annual Biotemperature in Degrees Centigrade (a)
1.5°
3°
6°
12°
24°
Mean Annual Potential Evapotranspiration in Millimeters
118
177
236
294
353
412
471
530
589
648
707
825
943
1060
1178
1296
1414
1532
1650
1768
1886
Potential Evapotranspiration Ratio
Average Total Annual Precipitation in Millimeters
62.5
125
250
500
1000
2000
4000
8000
64.00
32.00
16.00
8.00
4.00
2.00
1.00
0.50
0.25
0.125
0.0625
0.03125
SEMIPARCHED
SUPERARID
PERARID
ARID
SEMIARID
SUBHUMID
HUMID
PERHUMID
SUPERHUMID
SEMISATURATED
SUBSATURATED
SATURATED
Dry Tundra
Moist Tundra
Wet Tundra
Rain Tundra
Desert
Dry Scrub
Moist Forest (Puna) (a)
Wet Forest (Paramo) (a)
Rain Forest (Rain Paramo) (a)
Desert
Desert Scrub
Steppe
Moist Forest
Wet Forest
Rain Forest
Desert
Desert Scrub
Thorn Steppe
Dry Forest
Moist Forest
Wet Forest
Rain Forest
FROST LINE OR CRITICAL TEMPERATURE
Desert
Desert Scrub
Thorn Woodland
Dry Forest
Moist Forest
Wet Forest
Rain Forest
Desert
Desert Scrub
Thorn Woodland
Very Dry Forest
Dry Forest
Moist Forest
Wet Forest
Rain Forest

(a) t^{bio} = Mean of unit-period temperatures with substitution of zero for all temperature values below 0° C and above 30° C, respectively. (This formula is tentative pending further investigation)

Figure 2. An idealized transect through a Caribbean island in the Lesser Antilles.


Trade
Wind
Montane Zone
with Abundant Rainfall
Mostly Still Forested
Elfin
Woodland
Montane Thicket
and
Palm Brake
Greater Exposure
Temperature Falling
Seasonally Dry Zone
Now Mostly Cleared & used for
Agriculture
Rain Forest
Rainfall Decreasing
Littoral & Mangrove
Woodlands
Under the influence
of the sea and
fresh water runoff
Seasonal and Dry-Evergreen Forests
Littoral & Mangrove
Woodlands
Under the influence
of the sea with
little runoff
Swamp Forest

elevation at any place determines the Altitudinal Belt. In naming life zones the name of the Altitudinal Belt is dropped from the lowest Altitudinal Belt within a given Latitudinal Region. Thus, we refer to Subtropical Wet Forest, rather than Subtropical Premontane Wet Forest".

" Mean annual precipitation is the second variable used to define life zones. Precipitation lines traverse Figure 1 from the bottom upward and to the right at a 60°angle. The values shown increase from a low of 62.5 mm per year at the left-hand side of Figure 1 to values in excess of 8000 mm per year at the lower right-hand corner of the chart. As with biotemperature, the scale of mean annual precipitation is geometric".

" Mean annual biotemperature and mean annual precipitation bound in two directions the hexagons which circumscribe life zones on the chart. The final boundaries are formed by the potential evapotranspiration ratio, which is the ratio between mean annual potential evapotranspiration and mean annual precipitation. It is, therefore, a general statement of wetness or dryness of the environment as indicated by the names of the humidity provinces at the base of Figure 1. The potential evapotranspiration ratio line of 1.00, where mean annual precipitation equals mean annual potential evapotranspiration, is drawn diagonally across the chart. Life zones to the left of this line tend to have an annual water deficit, while life zones located to the right of this unity line tend to have an annual water surplus".

" The hexagonal boundaries which delineate the life zones connect the midpoints of the series of triangles resulting from the intersection of the precipitation, biotemperature, and potential evapotranspiration lines. The corners of each hexagon constitute transitional portions of the life zone and may contain many features common to adjacent life zones.

> These transitional areas are sometimes distinguished as separate mapping units".

Ewel and Whitmore (1973) found six lifezones in Puerto Rico and the Virgin Islands. Table 1 presents them in order of extension.

TABLE 1

LIFEZONES AND AREA IN PUERTO RICO AND THE US VIRGIN ISLANDS

LIFEZONE	TOTAL HECTARES	PERCENT OF TOTAL
Subtropical Moist Forest	542,220	58.4
Subtropical Wet Forest	212,480	22.6
Subtropical Dry Forest	165,030	17.6
Subtropical Lower Montane Forest	10,910	1.2
Subtropical Rain Forest	1,320	0.1
Subtropical Lower Montane Rain Forest	1,230	0.1

(1 hectare =2.47 acres)

A consideration of the Table shows that 98.6 percent of the area is covered by the first three lifezones. The latter three are found towards the tops of the mountains only in Puerto Rico and are very wet. They are quite unproductive for agricultural or forest crops, and are found almost entirely in their natural state. These high, wet, and often steep lands have importance and value for watershed protection, and almost all these lands are found in public forests.

The subtropical dry forest supports a complete forest cover rich in tree species and birdlife. It is not considered of good potential for commercial forest production. In P.R. and the U.S.V.I. and throughout the tropics, the forests of this zone are often converted to pasture, and the wood used for charcoal or fence posts. The smaller islands are drier and contain more of this lifezone (the dry lifezone in Puerto Rico itself occupies 13.8 percent). This limits the potential of smaller islands for commercial forestry operations, and heightens their need for effective conservation programs.

The subtropical moist lifezone is the largest in P.R. and U.S.V.I. Rainfall is between 1000 mm and 2000 mm per year. The zone is extensively exploited for agriculture and urban or industrial uses. It is a pleasant climate capable of growing luxuriant natural forests or productive plantations. It is the area for sugarcane, tobacco, pasture, pineapples, plantains and bananas, and many fruit trees.

The subtropical wet lifezone is found higher in the mountains of Puerto Rico where rainfall is above 2000 mm. This is coffee country. In these cool areas, pasture, bananas and plantains and other fruits will also grow well. Magnificient natural forests and productive plantations can also develope. Ewel and Whitmore (1973) give excellent and more detailed descriptions of all the lifezones encountered in P.R. and the U.S.V.I.

Within these lifezones very diverse and distinctive associations can arise. For example, mangroves and upland forests are both found in the moist zone. Whether the soil has formed from volcanic, limestone, granitic or serpentine rocks will strongly affect the type of forest or agricultural practices to be found in the area. These associations are discussed by Holdridge and Ewel, and an experienced observer can define and map them in the field, but this has not been done in P.R. or the U.S.V.I.

The most pronounced differences in natural vegetation in P.R. depend on lifezone and geological origin. Five basic geological formations can be found in Puerto Rico. They are alluvial, volcanic, granodioritic, limestone, and serpentine. Naturally, within each formation there may be many different rocktypes, and there are hundreds of soil types in P.R. (Lugo-Lopez and Rivera 1977; Briggs and Akers (1965). However forest growth and structure changes obviously only across the major geologic differences. These five geologic formations can be ovelayed with lifezones to form 17 geoclimatic regions (Figueroa and Schmidt 1982). The regions important for commercial forestry will be discussed briefly here.

Moist-alluvial- this is the zone of mechanized agriculture, urban development, and coastal mangroves and wetlands. These uses are considered of higher priority than forestry, and will probably preclude its inclusion in this zone in the future.

Moist-volcanic - this extensive zone is very important for forest development. It is a prime zone for growing Caribbean pine, mahogany, teak, blue mahoe, and eucalyptus. Where soils are poorer or have been degraded or on moderately steep slopes, agricultural practices have been ceased. Poor native pastures, especially where ferns invade, can be of very low productivity. Native forests which have regenerated can definately be developed for conservation or timber production purposes. However, my personal observation is that most of the abandoned lands in this region are deforested and are not regenerating rapidly into native secondary forests.

Moist-limestone - this is the fascinating area of karst or haystack topography. This is one of the areas of extensive agricultural abandonment in Puerto Rico. Except for flats between the hills that are really alluvial, little agriculture is practiced. Caribbean pine will grow here, but it is not a prime site for pine apparently because soils are less acid than volcanic or granodioritic soils. Mahogany, teak, and _Eucalyptus deglupta_ grow extremely well on the lower slopes of the rounded isolated hills of this region. Blue mahoe (_Hibiscus elatus_) grows very well in the moist bottom. There are three Commonwealth forests in this zone, and all contain well managed plantations of these species. The natural vegetation varies from some of the tallest forests on the island (40 meters) in the bottoms to a xerophitic vegetation on the hilltops. Thus this region is extremely rich and diverse in tree species. Its rugged beauty, numerous caves, underground drainage, and chrystalline rivers which appear and disappear, make it very important for recreation and conservation as well as production forestry.

Moist-granodioritic- the plutonic batholiths of Utuado, San Lorenzo and Vieques develope deep sandy soils. These soils were almost all farmed and large areas that have been abandoned. Caribbean pine grows phenomenally well on these deep infertile sands, producing impressively productive stands.

Moist and Wet Serpentine - in southwestern Puerto Rico about 30,000 hectares of serpentine crops out. These are considered the oldest rocks in Puerto Rico (Briggs and Akers 1965). The shallow soils that form from the magnesium oxide are low in nitrogen and phosphorus and very permeable. They contain nickel, cooper and other heavy metals, but apparently not in commercial concentrations. Agriculture has always failed on these lands, and tree growth is very slow (Weaver, 1979). Two Commonwealth Forests covering 7000 hectares are located in the wet and moist serpentine region. These forests contain important watersheds which produce extremely oligotrophic (clear and clean) water. On small areas within these regions a deep, red, infertile clay developes. This soil supports well developed plantations of Caribbean pine, maria (Calophyllum calaba) and, on a heavily fertilized tract, avocados. On the majority of this land which has shallow soil, protective natural forests and plantations are the proper use.

Wet-volcanic - Most of the wet lifezone in Puerto Rico is found over volcanic soil, and the main crop, as mentioned earlier, is coffee. Coffee was traditionally grown under shade trees, mostly three legumes, (Inga vera, Inga laurina and Erythrina poeppigiana) and one mahogany family tree (Guarea guidonia). Many coffee plantations were left untended in the late sixties and early seventies due most probably to rural emigration, alternative employment or support programs such as food stamps which made this type of labor unattractive to most of the work force.

Coffee bushes persisted along with many shrubs and trees which overgrew the plantations. During this period a shadeless coffee production scheme using nets for harvest was developed by Vicente Chandler and his group. (Vicente-Chandler et al. 1978). From the late seventies until present, the crop was again expanding its area of cultivation, apparently due to this new production scheme and a $2,000,000 programs of planting incentives amounting to $1,000/acre. The new production is more intensive and considerable areas of abandoned coffee shade are still to be found.

These areas present a substantial management challenge. They contain good proportions of commercially valuable trees, but most of their volume is in the three legumes mentioned above and other marginally valuable species (Birdsey and Weaver, 1982). Thus, left to themselves they will supply little useful timber for many years. These forests are dense and productive and apply excellent watershed and soil protection, wildlife habitat and recreational and aesthetic opportunities. Clear-cutting them for plantation establishment would be destructive and expensive, and very difficult to justify when so many deforested areas exist.

Although there is some evidence that thinning can produce accelerated diameter growth in natural forest (Wadsworth 1952, Weaver 1979), there is no indication that the sivilcultural cost of deadning or underplanting (alone or combined) can be offset by future profital harvest. In the Caribbean National Forest which is in this wet volcanic region, an extensive program of mahogany underplanting has been conducted for several years. Its future development will indicate the feasibility of this practice for a larger area of the island.

In deforested areas of this region pine and mahogany grow well on well drained sites and mahoe developes well on wetter sites.

HISTORY OF FOREST USE AND CURRENT STATUS OF RESOURCES

Land use, human impact, and productive potential are inherent parts of the forest ecosystem of P.R. and U.S.V.I. and much land use history was included where necessary to understand the nature of the ecosystems. Wadsworth's (1950) review of forest history is an excellent summary of events. Essentially all of the island was forested upon Columbus 1493 arrival. Agricultural and urban exploitation took place gradually, increasing steadily. Until the early twentieth century most of the wood cut was used for fuel or construction. But as early as the 1700s, wood was imported. The only exports were rare and valuable native species especially lignumvitae and satinwood (Guaicum oficinale and Zanthoxylum flavum). The advent of the national and global depression in the 1930s, combined with an increased population, impacted the U.S. territory of Puerto Rico heavily. Agriculture was pushed further up the hills across the island. By 1935 only about 2% of the most inaccesible and infertile areas had not been deforested at some time.

In the 1920s and 30s, the Federal Government had acquired about 50,000 acres of mountains land for forest and watershed protection. In the late 1930s and early 1940s, the Civilian Conservation Crops planted roughly 25,000 acres of timber trees that survive today, mostly in public forests. Public forest lands were increased through the 1950s and 1960s to about 90,000 acres and divided between Federal and Commonwealth (14 forest reserves) administration. Today 100,000 acres are in forest and natural reserves. In 1962 Caribbean pine (Pinus caribaea var. hondurensis) was first successfully established on the island, when it was discovered that its mycorrhizal symbiant was necessary for its growth. Through the sixties and seventies between 100-500 acres per year of timber trees were established on private lands, most of this being pine. About 200 acres per year of various species were planted on public forest lands.

This history would suggest that about 35,000 acres of timber plantations exist at present in P.R. This is only an estimate because no plantation inventory has been conducted. Birdseye and Weaver (1982) reviewed planting records in the annual report of the Institute of Tropical Forestry and determined that 95,000 acres had been planted. In 1981, Puerto Rico produced about 100,000 board feet of hardwood timber with a retail value of about $200,000. The 1981 imports of forest products to Puerto Rico totaled 409.5 million dollars. (Table 2). This amount is currently increasing annually by about 25 million dollars. For the past 40 years the growth in these imports has been tremendous. Estimates are: 1940-5-8 million dollars, 1950-20 million dollars, 1970-144 million dollars. Lumber imports by species and country of origin are shown in Table 3. In short P.R. and U.S.V.I. produced virtually no forest products compared to the tremendous demand and market for these products. Established plantation areas are considerable, but amount to only 1.5% of total land area. The 1973 land use inventory (Department of Natural Resources 1973) and the 1980 forest resources survey (Birdseye and Weaver 1982) indicated that 800,000 acres of Puerto Rico are regenerated in secondary forests. One half of Puerto Rico or at least 1.1 million acres of rural land, are abandoned to agriculture or grazing. At least 200,000 acres of this are suitable for commercial forestry (Wadsworth 1978,1982).

The tremendous growth in forested land, form five percent to forty percent of the total area, is due to a complex set of social, economic and cultural factors.

Agricultural exploitation of tropical lands is often cyclical. Lands of marginal agricultural productivity are exhausted by crooping, then abandoned to natural succession and, if and when some measure of fertility is restored by the development of secondary forest, the lands may be cleared or cropped again. Secondary forest reestablish fertility by penetrating the soil deep roots, absorbing

TABLE 2

1981 Major Wood and Wood Products Imports into Puerto Rico From United States and Foreign Countries

PRODUCT	UNIT OF MEASURE	TOTALS QUANTITY	 DOLLARS VALUE
Lumber	MBF(1)		
Hardwoods		11,084	5,889,309
Softwoods		83,451	21,850,462
TOTALS		94,535	27,739,771
Plywood Panels, Venners, Assemblies, bldg.	MSF(2)		
Hardwoods		97,112	15,667,724
Softwoods		58,187	16,970,598
TOTALS		155,299	32,638,322
Furniture & Part			38,711,669
Millwork (Siding-flouring moulding wood frame louvers)	Mixed		456,657
Poles and Piles	No.	195,529	3,486,446
Charcoal	S. Ton.	6,416	617,824
Paper-Paperboard and Products thereof Newsprint,craft,cigarrete, construction,paperboard, sanitary, corrugated -etc.	Lb.	529,540,822	277,830,450
Bamboo/Rattan sticks			1,442,275
Rattan webbing			22,455
cork			47,893
	MBF		

TABLE 2 (CONT.)

1981 Major Wood and Wood Products Imports into Puerto Rico From United States and Foreign Countries

PRODUCT	UNIT OF MEASURE	TOTALS QUANTITY	 DOLLARS VALUE
Hardboard	Mixed	3,248	1,023,832
Particle Board	Mixed	982,799	11,607,598
Densified Wood	LB	645,078	294,564
Wooden containers	No.	556,002	2,204,332
Ties	MB	288	126,370
Wood Carvings			126,452
All Others (Waste, shingles, blinds, doors, fences, dowel roods, cooper prod. forks, brooms mop holders, toolhandles, picture frames, toothpicks skewers, household utensils, coat hangers, prefabricated buildings, ladders, etc.)			
Wood articles not identified			2,886,999
Totals (Wood and Wood Products)			409,414,304

(1) Thousands of Board Feet

(2) Thousands of Square feet

Source: Puerto Rican Planning Board and Department of Commerce. Courtesy of José Zambrana and

TABLE 3

1981 Lumber Imports Into Puerto Rico By Species And Country Of Origin

SPECIES	COUNTRY	UNIT OF MEASURE	TOTALS QUANTITY	TOTALS DOLLARS VALUE
Softwoods				
Cedar (other)	Canada	MBF	599	144,205
	US	MBF	468	149,141
Douglas Fair	Canada	MBF	6,733	1,329,998
	US	MBF	764	357,033
Hemlock	Canada	MBF	30,544	5,972,512
	US	MBF	31	15,000
Pine	Canada	MBF	1,928	390,964
	Honduras	MBF	1,240	335,666
	US (Southern Ponderosa White)	MBF	31,986	10,769,915
Redwood	US	MBF	220	314,090
Spruce	Canada	MBF	7,548	1,212,428
Western Red Cedar	Canada	MBF	535	179,288
Other Softwoods	US	MBF	765	665,866
	Brazil	MBF	39	11,500
	Colombia	MBF	51	2,856
	Sub-Total		83,451	21,850,462

LE 3 (CONT.)

1981 Lumber Inports Into Puero Rico By Species and Country of Origin

SPECIES	COUNTRY	UNIT OF MEASURE	TOTALS QUANTITY	 DOLLAR VALUE
Hardwoods				
Mahogany	Brazil	MBF	3,261	2,096,303
Maple	US	MBF	1,417	815,038
Spanish Cedar	Brazil	MBF	260	87,418
	Colombia	MBF	291	55,441
	Honduras	MBF	98	95,192
	Surinam	MBF	10	4,882
Walnut	US	MBF	42	34,898
White Oak	US	MBF	2,075	477,789
Other Hardwoods	Brazil	MBF	1,255	730,832
	Colombia	MBF	459	117,026
	French Guiana	MBF	64	10,305
	Malaysia	MBF	23	15,015
	US	MBF	1,829	1,349,170
		Sub-total	11,084	5,889,309
		Total	94,535	27,739,771

nutrients and producing litterfall or organic material to enrich the soil.The speed of recovery of secondary forests is affected by the severity of abuse. A peak of agricultural activity in P.R. in the 1930s and 1940s degraded the productivity of larger areas of land leading to their abandonment.

Intensifying the degree of abandonment was the Commonwealth and Federal governments program of industrial development in the 1950s which continues to this day. The emphasis on industrial development led to more attractive employment opportunities in industry than in agriculture, and to a lower priority for agricultural programs. Complementing this increased availability of alternative employment was easy air transportation to the mailand U.S. Simply expressed, the pressure to scratch out a meagre living on steep infertile slopes was greatly reduced.

Industrial development, emigration opportunities, and social support programs have to the present continued to reduce dependence on marginal agricultural activities. Although unemployment is currently greater than 20 percent and higher in rural areas, many lands that could be farmed are not. However, the important point is that generally, any employer who offers the minimum wage ($3.15 at present) has no trouble hiring capable workers for farm or forestry work. The reduction of either support programs or alternative job opportunities would probably lead to larger scale land clearing and ecosystem degradation combined with emigration.

How the lands have responded to being spared the machete has been described in sections considering geological and climatic regions. In general, the potential for plantation forestry has been greatly increased as lands previously utilized for agriculture have become available for this less intensive land use. Also natural secondary forest may supply useful forest products in the future if methods for management and harvest can be developed or enough time passes so that valuable late successional species reach commercial size.

It is important to point out that the economic development of the island has placed much greater demand on other forest benefits such as clean water, reduction of reservoir sedimentation, recreation and research opportunities and wildlife. The development of natural secondary forest has helped the island's limited land base to continue to support present day Puerto Rican society.

The volume of wood in the secondary forest in P.R. is not great. Birdsey and Weaver (1982) reported 53 cubic meters in abandoned coffee plantations and 44 cubic meters in secondary forests. Undisturbed moist tropical forests often support more than 200 cubics meters of wood. Trends in the growth of forest area or volume are not yet known. The 1980 field work was the first comprehensive inventory, and future inventories in 1985 and 1990 should begin to indicate trends. Qualitative observations would lead one to believe that forest area is increasing slightly or is stabilized and that forest wood volume is increasing by 2-5 cubic meters per hectare. The only cutting occuring in these secondary stands is for fence ports which probably decreases overall volume increment little if it all.

The average wood volume increment of a softwood plantation in P.R.'s moist and wet forests appears to be about 25 cubic meters per hectare per year (Whitmore and Leigel 1980). This is equivalent to 2000 board feet per acre per year if production is averaged across the rotation. Proper thinning on an intensive basis should increase this and produce one thousand or more posts across a twenty year rotation. Hardwood plantation sawtimber production averages about one third of this. Thus the establishment of 100,000 acres of softwood plantation could produce 200 million board feet of lumber per year once sustained yield was achieved. In 1981, 83 million board feet of softwood lumber, 58 million square feet of softwood panels and veneers, and 195,000 espoles were imported to P.R. (Table 2). It appears that the estimate of available land and its productivity could satisfy current demand. However, demand is growing at about five percent annually and the planting of 5,000 acres per year for the next twenty years would result in the production of 200 million board feet per year on an sustained basis beginning in twenty years.

Similarly, were 100,000 acres of hardwood plantations established the production would be about 70 million board feet. In

1981, 11 million board feet of hardwood lumber and 97 million square feet of hardwood panel and veneer wer imported (Table 2). In this case as well, the current demand can support a planting program of this scale, and Puerto Rico would still be importing hundreds of millions of dollars of other products such as paper, furniture, veneers, composites, and others.

There is no evidence to indicate that this plantation production would not be sustainable. The less the area of plantations established the greater the future imports and their value. What role natural forests could play in future wood production in P.R. is an open question. The recent survey (Birdsey and Weaver 1982) indicates that there is adequate stocking in smaller size classes of commercially valuable species. Were a major plantation program to be launched it should be balanced with a practical research program on natural forest management for timber production.

The case of the U.S.V.I. is different in that a major opportunity for import substitution does not exist. The small land base of the U.S. Virgin Islands, approximately 305,000 acres, includes roughly 37,000 acres of forest and brushland. St. Croix, the largest island, has approximately 15,000 acres that could be considered to have a potential for timber production with a limited land base, relatively slow growth and a limited choice of species. The Virgin Islands will continue to rely on imports for most forest products. However, in spite of the slow growth, the potentially high value of the best suited species does present an opportunity for developing a forest resource that can contribute to the economy. The limited volume potential indicates utilizing the material locally for high value products, such as furniture and crafts. This would provide the greatest opportunity for jobs and to generate income locally.

Small and low value material removed during cultural operations can be used for fence posts and charcoal. Currently, the crafts industry is small and landowner returns negligible. For craftwood, volume can be deceptive because crotches in the trunk and branches provide figured wood and may be the most valuable part of the tree. Also, mahogany has proven to be an excellent street and yard tree, and in this limited environment, these trees can become valuable raw material when removed or replaced. Any inventory of the forest resources of the Virgin Islands should reflect these values. A street tree inventory of St. Croix is maintained, but volume is not included in the data.

The abandonment of the sugar cane industry several years ago decreased the amount of land in cultivation and some of this has reverted to brush. A growing population exerts additional pressure on the land base and wildfire(often incendiary) is a threat to young mahogany.

The total dependence on imports for softwood products will continue. Hardwoods for an enlarged furniture, crafts, posts and charcoal industry, are available, but the total available is not known. Some form of inventory is needed.

The brush and associated species of the forest and brush lands are important for soil and water management, as well as the extremely important esthetic values involved in the tourism industry for the drier areas of the Caribbean.

Virgin Islands National Park contains 14,000 acres of natural secondary forest and occupies nearly two thirds of the island of St. John. It is managed protectively for conservation values.

St. Thomas is small (22,000 acres), dry, and densely populated and developed. Its forests should be conserved without active management wherever possible.

FUTURE TRENDS UNDER CURRENT CONDITIONS

Once a forest production and utilization cycle is broken it is very difficult to reestablish. Investments are long term and benefits are delayed, therefore, other needs may seem more pressing. Since there is no economic activity in the forestry sector, the great majority of land owners and governmental decision makers are skeptical about possible future benefits. Successful programs require the simultaneous development of landowner extension and education programs, nursery production and delivery systems, and trained foresters and forest technicians. When the utilization phase is entered, loggers, sawmill operators, lumber treating and drying experts and marketing systems must be developed.

Since it takes years of planning and preparation to develope some of these systems, their simultaneous development is extremely complex. Furthermore, there are self-perpetuating aspects of this negative cycle. For example, young people do not study forestry because no commercial forestry is practiced, but it is difficult to develope forestry programs because of the lack of trained people.

Although most forestry activities are best carried by the private sector, there is little probability that the forestry cycle in Puerto Rico will be successfully reestablished without a comprehensive government stimulus program. In countries throughout the world private enterprise has successfully established the forestry cycle where valuable raw material already existed. Where effective forestry programs have developed in the Caribbean, in Jamaica and Trinidad for example, government planning has played a strong role (First Caribbean Forester's Workshop, St. Lucia, in preparation; Jamaica Forest Department 1971).

The amount of coordination and funding necessary to develope nursery facilities, trained foresters with practical know-how and skilled workers essential to woods operations can hardly be effected by the small landowner. Forest industry with a larger investment could coordinate such activities. However, there are several factors working against the feasibility of introducing a single large forest industry operation into P.R. or U.S.V.I. The U.S.V.I. do not have the land base or potential productivity to support such an industry. The high price of land in Puerto Rico ($1000 -$2,000 for forest land) is a strong deterrent. The nineteen percent internal rate of return that was observed in the feasibility study(Appendix I) would be drastically reduced by $100,000 -$200,000 of land acquisition costs. Also Puerto Rico still maintains a law against private individuals or corporations owning more than 500 acres of land. Perhaps most importantly, the social desirability and political feasibility of introducing a major corporate enterprise to dominate forest production is questionable.

Experience in Puerto Rico and other countries, has shown that the government cannot manage a profitable venture as efficiently as private enterprise. The role of government should be to support, coordinate, and demonstrate effective forestry practices, and stimulate the participation of the private sector, especially current land owners, in these practices. This participation should take place at all levels (ie. planting, harvesting, processing, transportation, retailing) as soon as possible.

An effective forest manager and technician education program should be established, and this must include assurance of job availability upon successful completion of training.

These trained foresters and technicians should operate hardemonstration projects in reforestation, stand management, harvesting, and utilization,and others should work in forest extension to carry this information to landowners. It is especially important to adequately utilize the forest resources in the established plantations that were described earlier. This entails special programs for these landowners, and developing marketing skills if necessary.

Adequate nursery production and delivery systems should be developed. Improved seed production programs should be established, and these will require research into tropical timber seed biology.

Research programs that address local, regional and international needs should be developed. The U.S., along with the rest of the industrialized world, is beginning to realize the ecological, economic, and political importance of tropical forests to the global community. Puerto Rico is the logical place to develope a comprehensive research program in tropical forestry and land use.

Without a significant government committment to a program of stimulating forestry, its development will come slowly if at all. Imports of forest products will continue to rise reaching the billion dollar range by the term of the century. Rural employment opportunities will continue to be very limited, and emigration to urban areas in P.R. or the U.S. or rising unemployment or both, will be the result. Official unemployment in P.R. today is 21% and some rural areas have rates as high as 35%. If income support programs are reduced and forestry is not developed, land clearing and farming on steep erodable slopes could occur. This would worsen erosion and sedimentation problems that are already acute.

The island of P.R. contains 2.2 million acres and a growing population now at 3.2 million. With this limited land base and the high density of people, the misuse of 200,000 acres that are best suited for commercial forestry and that can support one employee for every 8 acres would be extremely illadvised.

ACTION PROGRAMS

Puerto Rico has the legal (The Forest Law, No. 133 of 1975) and the administrative structure (through the Department Of Natural Resources) to develope a strong and effective Forest Service. In the past 15 years the Commonwealth government has not put a high priority on forestry, and programs have been maintained at a base level. In the last year there are stong indications that an increased emphasis will be placed on forestry, and programs may expand considerably in the next two years. Any future decisions by U.S. institutions should be based on an up to date assessment.

The most valuable areas of primary forest and all of the rare and endemic tree species are protected in the 100,000 acres of public forests. Since their establishment decades ago, protection policies for these unique areas have been fairly effective, and remain strongly supported today.

The State Forestry Grants programs of State and Private Forestry Division of the U.S. Forest Service is a very effective means of stimulating the Commonwealth Forest Service to support, coordinate, and demonstrate desireable forestry practices. Experienced foresters from the U.S. who are skilled in aiding state forestry organizations can be very effective in advising on nursery operations, logging techniques, utilization strategies, genetic improvement programs, research needs, extension practices and other elements of program development. The opinion developed here is that cooperative programs developed through the U.S. Forest Service's State and Private Forestry Branch and the Commonwealth and Virgin Islands Forest Service, can be very successful and should be strongly supported.

These programs may be contrasted to others which are meant to aid forestry or wildlife management programs, but are less effective. As a Commonwealth with close ties to the U.S., P.R. and as a territory, the U.S.V.I. are eligible for many state programs. Programs which may function well in states with relatively well developed forestry or wildlife programs may not be appropriate at all to P.R. or the U.S.V.I. situation. The flexibility and individuality of the State grant program means that its dollars accomplish more in the U.S. Caribbean environment.

Fomenting forestry and forest ecology training and education in P.R. and the U.S.V.I. is a difficult and very important issue. There are four basic approaches: 1) Puerto Rican and Virgin Islander students can be supported through scholarships to U.S. institutions. P.R. currently supports two students per year in such a program. This requires that these students be totally bilingual (if from P.R.) and education is more appropriate to temperate than to tropical forestry. 2) Students from the islands can be supported by scholarships to forestry schools in foreign countries such as Costa Rica, Venezuela, Trinidad and other countries were these institutions are found. 3) Short intensive training sessions in specific subjects may be held in P.R. and U.S.V.I. sponsored by the U.S. Forest Service Institute of Tropical Forestry, the Department of Natural Resources, U.S. V.I. Forest Service or local universities. 4) A forestry and forest ecology curriculum could be developed and established at P.R. and U.S.V.I. Universities. This last alternative is the greatest challenge, but it should be the final goal. In the initial stages it requires some form of guarantee of employment for graduates. It requires commitment and coordination at the highest levels of Federal and local forestry organizations and local universities. Faculty exchange programs with U.S. and foreign institutions, as well as a partial time commitments from local foresters and forest ecologists, will be essential in the initial stages.

Such a program can be combined with alternatives 1,2, and 3. Cooperative agreements for students as well as faculty exchange can be sought with U.S. and foreign universities. Local curriculum can be suplemented with a semester on the mainland and cooperating university students could conduct research projects on the islands.

Short training sessions can concentrate on practical hands-on skills that are so essential to forestry and so totally lacking on the islands today. In short sessions not only university students, but workers and technicians can be taught essential skills in nursery, logging, utilization, erosion control methods, water quality monitoring, plant and animal identification and others.

This program is an excellent candidate for a federal funding initiative. Local forestry organizations should guarantee positions for graduates. Local universities should supply facilities and organizational help. A position of training coordinator would have to be established in the U.S. Forest Service research project. This person would start by developing a detailed plan for implementing the program. Among many needs, the shortage of resource professionals in the islands is critical, and only a comprehensive program will produce results.

U.S. Forest Service research efforts in P.R. and the U.S.V.I. have been cut back continuously for the past few years. Only a large expansion could have a significant impact on local and international forestry.

Certainly the project should have adequate resources to absorb local talent when developed. A careful balance must be struck between results are as far reaching and international in scope and those that help resolve local forestry problems.

Other objectives that were mentioned are best accomplished through the State and Private Grants that were described earlier. Renewable Resources Evaluation of U.S. Forest Service Research has recently initiated a forest survey in P.R.'s secondary forests and published first results. This effort is in the process of expansion and should be continued. The Caribbean islands have been inhabited and exploited for hundreds of years. Forest surveys will document the recovery of secondary tropical forest, and establish an information base for their management. Secondary forest areas are increasing, especially in the American tropics, as primary forests are cut and left to regenerate. This process is further advanced in the U.S. Caribbean, and survey and management information may be of future use in many other tropical areas.

EFFECTS AND BENEFITS OF POLICIES

A vigorous program of forestry in P.R. would have a significant positive impact on environmental, economic, and social conditions. The current set of conditions and the framework of information that has been built up over the years have created a situation where forest development could take off quickly and become a major economic activity. To summarize the situation which has been described in depth earlier.

- Land is available. Land use surveys (Department of Natural Resources 1976) have shown that of more than 1,000,000 acres abandoned to other uses the at least 200,000 are suitable for commercial forestry.
- Successful species trials have shown that valuable timber species will produce very well on these lands. Hardwood trials 40 years old and pine trials 20 years old are reaching impressive maturity on hundreds of acres.
- P.R.'s imports of forest products have surpassed 400 million dollars and are growing at about five percent per year. The market for construction

- timber, fine hardwood and veneer can absorb the production expected from 200,000 acres. Prices and demand are excellent.
- Portable harvesting equipment and small scale operations return a good profit (See Appendix I), take advantage of P.R.'s extensive but narrow road system, and are compatible with the pattern of relatively small ownership and high land prices.

A rapid forestry development program could begin to adequately manage (ie. thin correctly and properly utilize the product) on the estimated 20,000 acres of accessible plantations on public and private lands. Reforestation plantings could double in area each year until 10,000 acres per year were planted every year after 1987. The longterm (after twenty years) benefits of this program would include about 200 million current dollars of import substitution, 25,000 direct jobs with a possible total stimulus approaching a quarter of a million jobs, most of them in depressed rural areas.

The lands to be planted are currently covered by degraded pastures, ferns and scrub. There are no quantitative projections of how much erosion, sedimentation, flooding and excessive water loss through rapid run-off would be reduced, but there is no question that these very acute problems would be substantially reduced. Nor is it easy to measure increases in wildlife populations, outdoor recreation, and turism, aesthetic and psychological benefits, and mitigation of temperature and air pollution. Not withstanding, these effects may be every bit as important as the presently quantifiable ones.

Short terms benefits would rise steadily until they reached long term levels. However, the realization that valuable products were contained in the 20,000 acres of existing accessible plantation could raise production and jobs to 10% of the long term goal almost immediately. The key figures are the number of acres of tree plantations that are successfully established each year, and the production of posts, poles or lumber from thinning and harvesting plantations. As the section on economics documented, jobs, imports substitution, and production will rise in accord with these figures.

CONGRESSIONAL ACTION

The recommendation of this report is not to create new programs or institutions but to revitalize and strenghthen existing ones. The State and Private Forestry and Forest Research branchs of the U.S. Forest Service are excellent institutions through which to promote an effective forestry program in P.R. and U.S.V.I. If Congress appropriates funds for and indicates its interest in developing forestry in the U.S. Caribbean, past events and trends would indicate that the Chief of the Forest Service will cooperate wholeheartedly in designing and implementing programs. The key people in this arena are the Secretary of Natural Resources of Puerto Rico, the Director of the Forest Service of Puerto Rico, the Director of the Forest Service of the U.S. Virgin Islands, the Forest Supervisor of the Caribbean National Forest and the Project Leader of the Institute of Tropical Forestry. The line of supervision to these latter two is through the Regional Forester for the Southeast and the Director of Research for the Southern Region. These individuals respond to the Washington office of the Forest Service.

If progress has been less than satisfactory in the past it is due to the comparative neglect of forestry on the islands by local and federal budget officials. This is understandable when the magnitude and importance of other economic problems facing the islands is considered; but it is correctable. It should be clear that billion dollar imports of forest products supporting tens of thousands of jobs off the islands in twenty years when much of this could be produced on the islands and simultaneously improve environmental conditions is an unacceptable scenario for the future. There may be little that Congress could do to interest local officials [illegible] these officials were unresponsive. But a strong federal program will undoubetly elicit cooperation on the local level. A simple communication to the respective Governors through their resident Commissioners would serve to alert them to the importance Congress placed on these programs. Thus the specific recommendations contained herein are relatively simple

1) State grants for forestry in P.R. and U.S.V.I. should be increased substantially and be used in accordance with the

recommendations of the U.S. Forest Service.

2) A substantially stronger research program in tropical or international forestry with particular emphasis on forestry in the greater Caribbean should be centered at the Institute of Tropical Forestry in P.R. The research program conducted by this Institute at Estate Thomas, St. Croix, should be reestablished. The Department of Natural Resources should be an active cooperator in this program.

3) Forest survey conducted cooperatively between the U.S. Forest Service and the Department of Natural Resources should be intensified in P.R. and international applications should be investigated.

4) A committee of educators, foresters, and forest researchers should be contracted to present a plan for local and international bilingual forestry education in P.R. and St. Croix. The Chief of the Forest Service and the Secretary of Natural Resources of P.R. should designate this committee.

5) The Congress should, through Washington representatives of Caribbean governments, indicate at regular intervals its interest in development of local forest resources to local government leaders. This should insure continuity of programs despite political changes.

APPENDIX I

COSTS AND BENEFITS(1)

In the U.S. where timber industry, logging and processing facilities are well established, the economic returns of logging a well developed stand of trees are seldom questioned. Since profits are made in logging, planting programs to replace this utilized and renewable resource are carried forth vigorously. In P.R., the U.S.V.I., and many others Caribbean islands these circumstances are very different. The following study was prepared to demonstrate the economic viability of an expanded forest tree planting and utilization program to the Commonwealth of P.R. Government. It is based on small scale, and thus relatively inefficient, but very flexible harvesting unit consisting of a small bulldozer skidder with a power winch and a portable sawmill crew and other necessary equipment.

Twenty landowners each with one hundred acres of moist mountain land that they wished to devote to commercial forestry banded together to form a forestry cooperative. They agreed to contribute equally to costs and share equally in profits. They agreed that the cooperative would plant one hundred acres of Caribbean pine each year and manage these plantations on a harvest rotation of twenty years. Each year the cooperative would decide which acres to plant, how many men to hire, and what equipment and materials to acquire.

From formal pine trials in Puerto Rico (Whitmore and Liegel 1980), from general observations on thousands of acres of pine

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(1) This section was originally prepared for the Governor of Puerto Rico's Council of Economic Advisors by the author. It may be used, published or reproduced in connection with the Council's need.

planted in P.R., and from Jamaica's pine yield tables (William Balmer, personal communication), the Cooperative knew that the pine would grow approximately as presented in Table 4. That is, if they planted the trees at a 6 foot spacing (1210 trees per acre) and thinned the plantation at 7, 10, 13 and 17 years and harvested at 20 years, the trees would grow one inch in diameter and six feet in height each year. This would yield the products shown in Table 1 according to the Scribner Rule, a final harvest of 54,270 board feet and a total harvest of 87,490 board feet. The total value of this harvest at present prices would be $47,835.

They calculated cost of harvesting based on actual model projects being carried out in pine plantations in Commonwealth Forests. For the first seven year post thinning they would need a crew of five men and the equipment shown in Table 5a. Operating costs included an eight hour round trip in a truck every other day to bring the product to market. Depreciating all equipment after five years and paying workers $4.00/hour, the economics looked fairly good.

For timber harvesting a seven man crew with a portable sawmill, a bulldozer with a power winch, and other equipment listed in Table 5b could average 1500 board feet per day. Costs of delivering the product were also included. This equipment was actually functioning and could work in any area of Puerto Rico where a bulldozer could enter with a trailer. In this operation the economics looked quite promising.

Table 4. Pine plantation production for one acre, Puerto Rico

YEAR	TREES/ACRE	BASAL AREA ($FEET^2$/ACRE)	PRODUCT 7 FOOT POSTS	 10 FOOT POST	 LUMBER BOARD FEET	VALUE PRODUCT 1982 PRICES ($)
82	1,210					
83						
84	1,000	242				
85		49				
86		87				
87		136				
88	1,000	196				
89	562	150	800			$1,200
90	562	196				
91	562	248				
92	275	150	400	250	7,000	5,100
93	275	181				
94	275	216				
95	162	150	200	100	8,800	5,100
96	162	173				
97	162	199				
98	162	226				
99	95	150	130	65	17,420	9,165
2000	95	168				

Table 5a. Costs and Value of Post Thinning

POST THINNING

(1) feeler, bucker	
(1) hauler	5 men - 200 posts/day
(2) debarker, stacker	($4.00/hour)
(1) truck driver	

16' truck	$16,000	Depreciation at five years
2 post peelers	5,000	
tools	1,000	
	$22,000	

Operation (Fuel)	$60.00/day

Yearly Costs:

Wages	-	$32,000
Depreciation	-	4,400
Operation (fuel, maintenance)	-	12,000
TOTAL		$48,400

Yearly Production: 40,000 posts

Value: $60,000

Table 5b. Costs and Value Timber Thinning

TIMBER THINNING

(1) dozer operator
(1) mill operator
(1) feeler bucker
(1) chocker setter
(1) helper
(1) post hauler
(1) truck driver

7 men - 1,500'/day + all posts
($4.00/hour)

bull-dozer	$40,000
sawmill	12,000
post peeler	2,500
16' truck	16,000
tools	2,000
	$72,500

Yearly Costs:

Wages	- $44,800
Depreciation	- 14,500
Operation (fuel, maintenance)	- 20,000
TOTAL	$79,300

Yearly Production: 300,000 Board feet
20,000 posts

Value: $170,000

Table 6 Operation on 2,000 Acres

YEAR

TRACT (100 A)	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	2000	2001	2002	2003
1	Plant 6 HY							Thin-7			Thin-10			Thin-13				Thin-17			Harvest Plant	
2		Plant 6 HY							Thin-7			Thin-10			Thin-13				Thin-17			Harves Plant
3			Plant 6 HY							Thin-7			Thin-10			Thin-13				Thin-17		
4				Plant 6 HY							Thin-7			Thin-10			Thin-13				Thin-17	
5					Plant 6 HY							Thin-7			Thin-10			Thin-13				Thin-1
6						Plant 6 HY							Thin-7			Thin-10			Thin-13			
7							Plant 6 HY							Thin-7			Thin-10			Thin-13		
8								Plant 6 HY							Thin-7			Thin-10			Thin-13	
9									Plant							Thin-7			Thin-10			Thin-1
10										Plant							Thin-7			Thin-10		
11											Plant							Thin-7			Thin-10	
12												Plant							Thin-7			Thin-1
13													Plant							Thin-7		
14														Plant							Thin-7	
15															Plant							Thin-
16																Plant						
17																	Plant					
18																		Plant				
19																			Plant			
20																				Plant		

Finally they wished to determined how these economic analyses would apply to the entire project. Table 6 shows which operation would be occuring in different areas in each year. After twenty (20) years the operations are the same every year. They simply rotate from tract to tract. This is sustained yield forestry. Table 7 shows these same operations by year as well as the production, its value on today's market and the cost of this production. Columns describing operations show man-years (MY) required to plant to 100 acres per year. They also show post set years (PSY) and timber set years (TSY). These numbers are derived by calculating production on 100 acres from production per acre in Table 4 and then calculating how many work teams or units would be necessary to harvest this production as shown in Table 5a and 5b.

Value of product first exceeds costs in year 13, but income begins in year 7. After year 13 the operation becomes increasingly profitable, and after regularization in year 20 the gross sales are about 4.5 million dollars and costs are about 2.7 million dollars.

A breakdown of costs is shown in Table 8. Costs in Table 7 are the total of all costs in Table 8. Total man-years required for all operations is calculated by suming all the workers that would be necessary in all the work units. This is an indication of laborer jobs provided by the project. . Equipment is acquired as needed by the project. If 2.5 work teams or units could handle the timber production, then 3 sets of equipment must be acquired. It is assumed that all equipment working days, of five years. Equipment acquisition costs vary considerably under these assumptions.

Table 7 Costs, production, operations and cash flow

YEAR	Plant 100	THIN-7	THIN-10	THIN-13	THIN-17	HARVEST/PLANT	COSTS	POSTS	TIMBER	VALUE
82	6 HY						69,400			
83	6 HY						54,400			
84	6 HY						54,400			
85	6 HY						54,400			
86	6 HY						54,400			
87	6 HY						69,400			
88	6 HY						54,400			
89	6 HY	2.1 PSY					222,800	80,000		120,000
90	6 HY	2.1 PSY					156,800	80,000		120,000
91	6 HY	2.1 PSY					172,800	80,000		120,000
92	6 HY	2.1 PSY	2.33 TSY				537,220	80,000	700,000	470,000
93	6 HY	2.1 PSY	2.33 TSY				319,720	80,000	700,000	470,000
94	6 HY	2.1 PSY	2.33 TSY				319,720	80,000	700,000	470,000
95	6 HY	2.1 PSY	2.33 TSY	2.93 TSY			809,020	80,000	1,580,000	910,000
96	6 HY	2.1 PSY	2.33 TSY	2.93 TSY			579,520	80,000	1,580,000	910,000
97	6 HY	2.1 PSY	2.33 TSY	2.93 TSY			765,020	80,000	1,580,000	910,000
98	6 HY	2.1 PSY	2.33 TSY	2.93 TSY			547,520	80,000	1,580,000	910,000
99	6 HY	2.1 PSY	2.33 TSY	2.93 TSY	5.81 TSY		1,507,700	80,000	3,322,000	1,781,000
2000	6-HY	2.1 PSY	2.33 TSY	2.93 TSY	5.81 TSY		1,044,200	80,000	3,322,000	1,781,000
2001	6 HY	2.1 PSY	2.33 TSY	2.93 TSY	5.81 TSY		1,064,200	80,000	3,322,000	1,781,000
2002		2.1 PSY	2.33 TSY	2.93 TSY	5.81 TSY	18.09TSY+6HY	3,991,740	80,000	8,749,000	4,494,500

Table 8 (Breakdown)

YEAR	MAN-YEARS	WAGES	EQUIPMENT - ACQUISITION	OPERATION	SUPERVISION ACCOUNTING, ETC.
82	6	38,400	16,000	1,000	14,000
83	6	38,400	1,000	1,000	14,000
84	6	38,400	1,000	1,000	14,000
85	6	38,400	1,000	1,000	14,000
86	6	38,400	1,000	1,000	14,000
87	6	38,400	16,000	1,000	14,000
88	6	38,400	1,000	1,000	14,000
89	16.5	105,600	66,000	25,200	26,000
90	16.5	105,600	-0-	25,200	26,000
91	16.5	105,600	16,000	25,200	26,000
92	32.8	209,920	217,500	71,800	38,000
93	32.8	209.920	-0-	71,800	38,000
94	32.8	209,920	-0-	71,800	38,000
95	53.3	341,120	261,500	130,400	76,000
96	53.3	341,120	32,000	130,400	76,000
97	53.3	341,120	217,500	130,400	76,000
98	53.3	341,120	-0-	130,400	76,000
99	94.0	601,600	507,500	246,600	152,000
2000	94.0	601,600	44,000	246,600	152,000
2001	94.0	601,600	64,000	246,600	152,000

In actual year to year operations they would be more regular and less costly. Operational costs are fuel and maintenance. Foresters,accountants, salemen, and secretaries are added in proportion to operations and production. Twentyfour managers for 221 workers are in place in the twentieth year.

After year 13, when more than one million board feet per year are being produced, sawmills of larger capacity would probably replace portable sawmills because they are more efficient. This would tend to reduce costs and increase production. However, portable sawmills are maintained throughout to simplify the analysis and make it more conservative.

If inflation continues it will increase costs and values. Over an extended period in the past forest product stumpage prices in the U.S. have increased at a rate approaching 3% over inflation (William Balmer, personal communication). Since shortages of forest products are projected in the U.S. and especially world wide in the next 15-25 years, it is reasonable to assume to that their prices will increase faster than rural wage rates in Puerto Rico. World lumber prices and inflation in general will be coupled to fuel prices, but the operation is more labor than fuel intensive, by a factor of 3. Increasing prices by three percent annually would make the project much more profitable, but again the analysis presented is conservative.

Table 9 shows an economic analysis. Any business which involves a long time period between initial expenditures and later returns

TABLE 9. ECONOMIC ANALYSIS

YEAR		CASH FLOW
82	-	69,400
83	-	54,400
84	-	54,400
85	-	54,400
86	-	54,400
87	-	69,400
88	-	54,400
89	-	102,800
90	-	36,800
91	-	52,800
92	-	67,220
93	+	150,280
94	+	150,280
95	+	100,980
96	+	330,480
97	+	144,980
98	+	362,480
99	+	273,300
2000	+	736,800
2001	+	716,800
2002	+	502,760
2003	+	2,170,260

should be analyzed through compound interest methods. This requires analysis of one 100 acre tract which is planted, thinned and harvested in the same way. Table 10 shows operations and cash flow on 100 acres. Total profits after 23 years are $1,621,000. The first sales come in the seventh year and after the eleventh year the profits are steady. The internal rate of return on this investment is greater than 19%.

Operations on the entire 2000 acres supply a number of other benefits. The project employs 245 people once it regularizes at year 20. This is .12 direct jobs per acre. Therefore a reforestation program of 200,000 acres would produce 24,000 direct jobs. The multiplier factor for forest products jobs in the U.S. is estimated at 5 to 10 times. Jobs are created in drying and treating the lumber, wholesaling and retailing lumber, sales of fuel and machinery needed in the operation, furniture making, crafts and construction jobs, and of course, all the services that the employed people utilized and pay for.

Table 10 Operation and Cash Flow on 100 Acres

YEAR	WAGES/OPERATIONS	AVAILABLE RAW MATERIAL	HARVESTES RAW MATERIAL	EQUIPMENT ACQUIRED	VALUE HARVEST	SUPERVISION	NET CASH FLOW	TOTAL COSTS
82	38,400			12,000	0	0	- 58,400	58,400
89	44,000	80,000 P	40,000 P	22,000	60,000	12,000	- 18,000	78,000
90	44,000		40,000 P	-0-	60,000	12,000	+ 4,000	56,000
91	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
92	64,800	700,00 BF	300,000 BF	72,500	150,000	14,000	- 1,300	151,300
93	64,800		300,000 BF	-0-	150,000	14,000	+ 71,200	78,800
94	21,600		100,000 BF	-0-	50,000	14,000	+ 14,400	35,600
95	64,800	880,000 BF	300,000 BF	-0-	150,000	14,000	+ 71,200	78,800
96	64,800		300,000 BF	-0-	150,000	14,000	+ 71,200	78,800
97	60,480		280,000 BF	72,500	140,000	14,000	- 6,980	146,980
98	-0-			-0-	-0-	-0-	-0-	-0-
99	129,600	1,742,000 BF	600,000 BF	72,500	300,000	24,000	+ 73,900	216,100
2000	129,600		600,000 BF	-0-	300,000	24,000	+146,400	153,600
2001	117,000		542,000 BF	-0-	271,000	24,000	+130,000	141,000
2002	324,000	5,427,000 BF	1,500,000 BF	217,500	750,000	48,000	+160,500	589,500
2003	324,000		1,500,000 BF	-0-	750,000	48,000	+378,000	372,000
2004	259,200		1,200,000 BF	-0-	600,000	48,000	+292,800	307,200

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Background Paper No. 6

FORESTRY IN PUERTO RICO: A CASE STUDY IN SUCCESSFUL ORGANIZATIONAL CHANGE

(Authors' Draft)

by

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ABSTRACT

During the last five years (1981-85), a significant revolution ocurred in sustainable renewable resource management in Puerto Rico. A major forestry initiative was undertaken by the Department of Natural Resources (DNR) with enormous positive ecologic, economic, and social impacts for the island.

A significant re-orientation and development of the PR Forest Service occurred. There is a new organization, professional personnel, and adequate budget. DNR has undergone a successful organizational change to accomodate its new forestry initiative. The agency has developed public, political, and internal constituencies that support increased forestry management activities. This case study provides the opportunity to assess the conditions for successful organizational change in a local government resource agency in the U.S. insular Caribbean.

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Chapter 1

INTRODUCTION

During the last five years (1981-85), a significant revolution has ocurred in sustainable renewable resource management in Puerto Rico. A major forestry initiative has been undertaken by the Department of Natural Resources (DNR) with enormous positive ecologic, economic and social impacts for the island. For the first time, the agency is managing forests as a sustainable renewable resource, with a new organization, professional personnel and an adequate budget. The effort comprises preservation and conservation of a system of ecologically valuable forests and natural areas. It also entails the management and development of forest plantations in the public forest system and on other government and private lands, thus creating the basis for a private forest industry on the island.

T· Puerto Rico forestry initiative is responsible for a profound and major change in perception within the Puerto Rico Forest Service (PRFS) and the DNR. For the first time, DNR confronted the challenge of initiating active, professional management of the 14 insular forests and other natural areas within its jurisdiction. In 1981, the agency began to actively take care of the conservation and management of Puerto Rico's ecological patrimony, which up to then had been taking care of itself, with only minor interventions from man. DNR and the PRFS ceased being passive observers, and became major actors to promote wise resource conservation and forestry development. A unique "espirit de corps" developed within the new, growing PRFS, as they understood and carried out their mission, and as the rest of the Department and the Puerto Rican citizenry began to appreciate and support their monumental task.

From 1981 on, there was an enormous change in quality, quantity, and breadth of forestry activities performed by the PRFS and DNR. Quality and performance improved dramatically because professional resource managers directed the effort, with invaluable technical assistance from the United States Forest Service (USFS), and the enthusiastic support of the DNR Secretary. The breadth of activities in the new forestry initiative included:

- forest planning (both long and short range);
- forest inventories;
- forest management, including management of vegetation, endangered species, and water resources;
- forest recreation and tourism;
- plantation establishment, management and utilization;
- timber management programs including demonstration of logging, treatment and utilization of posts and lumber;

- tree nursery development and seedling production and distribution;
- seed production and genetic improvement of seed source for major plantation species;
- reforestation on private and public lands;
- design and implementation of new forestry regulations;
- law enforcement on forests;
- forestry research; and
- programs to enhance public awareness, environmental interpretation, and education.

Chapter 2

FORESTRY PROGRAMS IN PUERTO RICO

Forestry in Puerto Rico: 1898 to 1930

Forestry in Puerto Rico began in the early 1900's. In 1903 the Federal government acquired 18,000 acres in the Luquillo Mountains, creating the only tropical national forest: the Caribbean National Forest (CNF).

The Puerto Rico insular government was run by the U.S. military (1898 to 1917) and by appointed civil governors (from 1917 on). Slowly, the island governors began to set aside large tracts of lands as a forest system. The mangrove forests of Boqueron-La Parguera, Aguirre, Ceiba and Pinones were designated as insular forests. Mona Island, a limestone plateau of 14,000 acres rising from the deep oceanic waters between Puerto Rico and Hispaniola became an extraordinary element of the system. This entire island is a natural reserve with superb arid landscapes and unique species of flora and fauna. Guanica, the magnificent dry forest in the southwest of Puerto Rico, and the Maricao forest, located in the central mountain range on serpentine soils, were declared insular forests by the 1920's. Thus, in a slow process, the government set aside aproximately 30,000 acres on seven different sites: an emergent Puerto Rico Insular Forest System.

Through the decades of the twenties and thirties, the Insular Forest Service was administered under a cooperative agreement by the Supervisor of the CNF. There was no expertise within the Puerto Rican government to properly manage the insular forest system.

Forestry in Puerto Rico: 1930 to 1980

In the 1930's, during the great depression, President Franklin D. Roosevelt created various Federal programs to alleviate unemployment and economic hardship. Those programs provided the government of Puerto Rico with substantial funds ($60 million). Governor Rexford Tugwell created the P. R. Reconstruction Administration, and wisely decided to invest a part of the funds in acquiring large tracts of forested lands. Thus, Puerto Rico's insular forest system was strenghtened by the addition of approximately 30,000 acres. When farms were acquired, persons living on them were given the opportunity to continue this during the lifespan of the resident. The management of these forests was then delegated to the Federal government through a cooperative agreement with the Supervisor of the CNF.

Across the island, the system of forest reserves was slowly established and consolidated. There were four mountain forests, protecting the watersheds of steep wet ridges and peaks; four limestone forests, preserving striking examples of karst topography and its related vegetation; four forests to preserve coastal mangroves; and two dry forests, one on serpentine and the other on limestone.

The other Federal program initiated by President Roosevelt was the Civilian Conservation Corps (CCC). It operated in PR from 1935 to 1943 and had a major impact on the insular forests, providing jobs for 2,500 forest workers. Forest roads and trails were built, 20,000 acres of plantations of hardwoods (teak, eucalyptus, mahogany and native species) and softwoods (pine) were planted, and some recreation areas were built. Ten million dollars were wisely spent on the forest system. But as the CCC program ended during the decade of the 1940's, the forests fell into oblivion, with no conservation, management or development activities ocurring within them.

In 1952, the present-day Commonwealth of Puerto Rico was established. At that point, all of the insular forest reserves except the CNF were transfered to the new government. The USFS and its Institute of Tropical Forestry (ITF) (within the research branch) have continued to operate, and have provided invaluable assistance to local forestry programs.

Initially, the insular forest system was administered by the P.R. Department of Agriculture. However, there was not much of a constituency among the trees, and the

Department devoted most of its attention and funds to the problems of sugar, coffee, tobacco, and other edible products. Very little was done to improve the forests, beyond minimally mantaining recreation areas and trails. The advice of the USFS was largely ignored during a period when great strides were being made towards the island's industrialization.

With the growth of concern about environmental matters and natural resources during the late sixties, a unit was created in the PR Department of Public Works to deal with natural resources. The Environmental Quality Board was established as a separate agency. However, the primary concern of both entities was water and water quality.

On June 20, 1972 law number 23 created DNR as a cabinet level executive agency. It is responsible for the conservation, management and development of all natural resources, including soil, water, forests, fish, wildlife, minerals, and marine and coastal resources. In 1973, DNR was given responsibility for acquiring forest lands, managing forest nurseries, and administering the original Puerto Rico Forest Law. Previously these functions had been assigned to the Department of Agriculture.

The new DNR was first organized in terms of its major functions: administration, operations, planning, and research. Forestry was one of the operational activities under the Terrestrial Resources Area (Figure 1). From 1973 to 1980 little was done to improve the existing forests, beyond minimally maintaining recreation areas and trails. DNR's Planning Area undertook to formulate policy and to develop plans for the forest system. However, the initial concerns were with improving forest recreational facilities, rather than with comprehensive forest management. Furthermore, there were other more pressing problems for the various Secretaries of DNR, and despite the proposals advanced by their planning staff they did not devote much time to the forests. Still, some ideas were germinating, and they finally produced results.

Chapter 3

INSTITUTIONAL CHANGE

A. The Policy Change

The need for a policy change

Hilda Diaz-Soltero was appointed Secretary of DNR in June, 1981. Ms. Diaz was the first Secretary named with technical and academic preparation in natural resources (geology, ecology, and botany). This gave her a unique opportunity to strengthen the agency, being able to agressively promote natural resources at the highest administrative, legislative, and political levels while simultaneously understanding the complexities of natural resources conservation, management and development on a small, overpopulated, and polluted tropical island. The process by which DNR's priorities were chosen during her tenure is a unique blend of wise resource management, economic realities, and political necessities.

In the summer of 1981 the political scenario in Puerto Rico was complex. The New Progressive Party (NPP), the statehood advocate, had won a mandate for an additional term of four years by a slight margin of approximately 3,000 votes. Both chambers of the Legislature had been won by the Popular Democratic Party (PDP), the pro-Commonwealth group. Political spirits were depressed: neither of the political parties had won a clear mandate to govern the island. Government should have been done by concensus, but in reality most of it was done by confrontation of the two powerful factions. From the NPP's political point of view there was a need to be bold, to be creative, and to present programs that would have visible, positive, lasting, and profound impacts upon Puerto Rico.

The economic realities of the time were most distressing. President Reagan, with the masterful mind of his Office of Management and Budget Director, David Stockman, began to systematically reduce the Federal government's role, its agencies' size and number of personnel. Puerto Rico's status as a territory of the United States, with only one Resident Commisioner in Congress, made it particularly vulnerable to the cuts in Federal government funds and programs. The agenda of priorities for the Republican Party seemed to focus more on commercial development of natural resources rather than strict conservation and protection. Thus, Puerto Rico could not launch a major natural resources initiative counting on the Federal government as a prime funding source.

Within the island's scenario, the economic realities were even harsher. During 1981 and 1982, the island went through economic hard times second only to the Great Depression of the 1930's. Government agencies had to absorb a $92 million cut to maintain a balanced budget, as is required by Commonwealth law. On this occassion, DNR cut $800,000 from all programs (except forestry) in equipment, materials, and administrative expenses, but not personnel. To summarize: the island government's economic situation was very precarious; funds were not sufficient for all existing programs; and the prognosis for the immediate future was quite poor. DNR would have to re-evaluate its priorities, re-examine existing programs, re-distribute its budget, and very cautiously approach expansions or new programs.

Within the context of these economic realities and political needs, the new DNR Secretary initiated an analysis and evaluation of the agency's existing programs, as well as of other natural resources management programs not established within DNR at the time. Forest management programs were designated as the top priority, closely followed by environmental education and adquisition/ protection of valuable ecological lands. Thus, the conservation and management of the island's forests and other natural areas, and promotion for the development of a private forest products industry became a major DNR effort during 1981-84.

There was great potential for the development of Puerto Rico's forest resources for various reasons. First, the land was available. Recent land use and forest resource inventories had shown that half of the island's 2.2 million acres were in abandoned agriculture or grazing. About 200,000 of these acres were suitable for commercial forest production. Also, secondary forests had regenerated on

800,000 acres, bringing to 40% tree cover an island that was 90% deforested in 1935 (Schmidt, 1982).

Second, there was a large market on the island for forest products. In 1981 Puerto Rico spent $450 million on imported forest products. That amount was growing by $25 million per year and accounted for one fifth of the island's negative balance of payments. There was a demand for 2 million treated fence posts per year (Schmidt, 1982). Treated lumber, quality hardwoods, furniture, and paper all sell in Puerto rico for about 150% of their retail price in the United States.

Third, there were experiments that demonstrated successful establishment of hardwood and softwood tree species, and a fast rate of tree growth. Caribbean pine (Pinus caribaea) was successfully established in Puerto Rico in the 1960's and had reached impressive maturity on hundreds of acres. Thousands of acres of valuable hardwoods had been planted in the insular forests in the 1930's and 40's by the CCC, and these too exhibited excellent development and value. The plantations needed thinning and proper forest management practices. Thus, the raw material to initiate a forest products demonstration project was available in these insular forest plantations.

Fourth, the island's unemployment had reached an official rate of 24%, although the real rate probably was closer to 35 or 40%. Unemployment was most critical in the central mountainous area, coinciding with the best sites for forestry activities.

Once the policy decision was taken, DNR was eager to demonstrate that forestry could and should be an important element of the Island's economy, providing jobs and forest products. At the same time properly managed forests and reforestation could provide other ecological benefits, such as:

- minimizing or preventing soil erosion,
- creating new topsoil on previously denuded areas,
- reducing the intensity and frecuency of floods,
- improving the quality and quantity of surface and subterranean waters,
- reducing processing and maintenance costs of water for domestic, agricultural or industrial uses,
- minimizing siltation in rivers and coastal waters, thus reducing the mortality of coral reefs and the reduction of fishery resources,
- minimizing noise,
- decreasing tropical temperatures by 5 to 15 degrees F.,
- promoting the retention of water in the soil and avoiding desertification and soil laterization,

- providing habitat for wildlife and endangered species,
- improving air quality by providing oxygen and trapping particles suspended in the atmosphere,
- providing opportunities for public passive recreation to Puerto Rico's increasing urban population, and
- providing opportunities for tourism.

Redefinition of forestry goals

The forestry program began with four basic goals. Three addressed the development of a forests products industry:

1. To utilize established plantations in the public forests as demonstration projects.
2. To accelerate timber planting on private lands.
3. To promote the reforestation of public lands outside the insular forest system.

One addressed the conservation and management of the insular forest system:

4. To create a new administrative area within DNR that centralized the management of forests and natural areas.

Legislation

In 1975, legislation was enacted that gave the PRFS a separate identity within DNR. The Puerto Rico Forest Law (Number 133, approved July 1, 1975) clearly established public policy for forestry. It recognized the extraordinary value of forests to conserve and restore the ecological balance; to conserve soils, water, flora and fauna; to provide wood products; to provide a unique environment for public recreation; and to provide a source of rural employment. The Law states that forests shall be maintained, conserved, protected, and expanded. Forest products and benefits shall be used efficiently and completely. The Law creates the Puerto Rico Forest Service. It gives guidelines for the creation and management of a forest system. And it outlines proper activities that may occur within the forests, such as reforestation, research, public education and recreation, law enforcement, utilization of wood products and limited concessions for the rental of forest acreage for special uses. The Law also states the acts to be considered illegal in the forests, such as damage to the trees, burning, hunting, grazing, and land invasion. It states illegal acts on forested areas outside the insular forest system. The Forest Law promotes government programs for reforestation and forest products utilization. It provides for the designation of State Auxiliary Forests on private forested lands, giving owners the incentive of property tax exemption. The Law specifically promotes forestry as a form of rural employment. It creates a valuable mechanism for forestry development by creating the "Special Fund for Forestry Development" within DNR. This fund receives all monies from activities on the insular forests, including recreation, land rental, revenues from forest products, and special forest uses. Finally, the PR Forest Law states penalties for violations to the statute.

It is evident how comprehensive the enacted PR Forest Law is. Unfortunately, it was not until 1981 that the major effort to implement it was initiated.

Political commitment

To initiate, develop and, more importantly, successfully implement a major government program, particularly one regarding natural resources, there must be absolute political commitment from many sectors. In the case of DNR, these included the executive and legislative branches of the Puerto Rican government and the Federal agencies.

Within the insular executive government, a major political commitment was necesary from:

- the Secretary of DNR,
- the Governor of Puerto Rico,
- the Governor's Economic Advisory Council, and
- the PR Office of Management and Budget.

The Secretary of DNR, having established forestry as a top priority, was committed to initiate and successfully develop the new program. She was aware that the major reforestation effort would have multiple beneficial impacts not only on forestry resources, but on many other natural resources as well: soil, water, air, wildlife, and fisheries, as well as on recreation and tourism activities. A variety of forestry products would be produced, to substitute imports. The forest industry had the eventual capacity to create 30,000 jobs. Thus, with only one activity, reforestation on public and private lands, major positive ecological, economic, and social impacts would result. These were the messages for her to carry to obtain the political commitment from others.

DNR lacked the forestry professionals and technical personnel to carry out such an ambitious undertaking, and the Secretary aprocached the USFS for the support and commitment to provide such expertise. In a series of meetings in October 1981 with the three branches of the USFS (State and Private Forestry, Research, and National Forests) and in a meeting with the Chief of the USFS, Mr. Max Peterson, the Secretary explained the new forestry program, its potential for the island's economy and natural resources, and what was needed to implement it. A plea was made for technical assistance, help in the identification of bilingual forestry professionals with experience in the tropics, and economic support for the forestry initiative. The USFS Chief committed himself to all of these, and at the end of the meeting DNR's Secretary had received a commitment for $250,000, as well as an additional $100,000 to be earmarked as incentives for Puerto Rican farmers to reforest their lands.

Having received the commitment for technical assistance and an initial sum of a quarter of a million dollars, DNR's Secretary initiated a major campaign to convince the appropiate individuals and institutions of the desirability of the forestry program. The first to be approached and convinced of the political, economic, social, and ecological benefits of the program was the Governor of Puerto Rico, Hon. Carlos Romero-Barcelo. In November 1981 Governor Romero not only approved the plan, but gave his enthusiastic and continuous support. The Governor asked DNR's Secretary to present the forestry program to one of the most powerful advisory bodies, the Governor's Economic Advisory Council, so that they could study the program in detail. Before doing this presentation, the Secretary asked Ralph C. Schmidt, PRFS Chief, and Dr. Frank Wadsworth, world authority on tropical forests, to prepare a document on the economic viability of commercial production of Caribbean pine in Puerto Rico.

The P.R. Office of Management and Budget (PROMB) received DNR's budget request later that same month of November 1981, and it included the new forestry initiative. A comprehensive presentation was made by the Secretary and the PRFS Chief, including a summary of the meetings with the USFS Chief and staff, as well as with the Governor. Chapter 3 and Table 1 give details on annual forestry budgets. It was difficult to convince PROMB to appropiate funds for DNR, an agency that did not enjoy the highest priority in such economically difficult times. But for PROMB, the Governor's favorable reaction and the financial backing of the USFS assured the tacit approval of the program.

The Commonwealth's Budget was presented to the Legislature in February 1982. DNR's budget was presented and discussed on March 1982 in three committees. In the Senate, the Agriculture and Natural Resources Committee, presided over by Sen. Justo Mendez, was very interested in he new forestry program. Senator Mendez, who had long experience in agriculture and natural resources, was excited to finally see concrete proposals to implement the public policy declared within the Forest Law. He became a strong supporter of the forestry program, and thereafter met with DNR's Secretary several times to be informed of developments within the program. The Senate and the House of Representatives Budget Committees also analyzed and approved the program. They were particularly enticed by an effort that would create jobs and substitute wood imports.

In April 1983 the forestry program was presented to the Governor's Economic Advisory Council through a study entitled "The Economic Viability of Producing and Processing Caribbean Pine Lumber in Puerto Rico". Although some Council members were skeptical of the long time period (20 yrs) involved in a Caribbean pine rotation, the forestry initiative was accepted as an alternative for economic development, particularly in the mountainous central region of Puerto Rico.

During the spring and summer of 1983, a deadlock over the 1983-84 Commonwealth budget developed between the Governor and the Legislature. A "Dialogue Committee" representing both sides was formed with the following composition:

- Virgilio Ramos, Aide to the Governor in charge of Public Policy and Legislative Affairs
- Jose Enrique Arraras, President, Budget Committee of PR House of Representatives
- Miguel A. Deynes-Soto, President, Budget Committee of the PR Senate
- Ramon Garcia-Santiago, Secretary of the Legislature
- Jose Granados-Navedo, member of the House of Representatives Budget Committee
- Luis Montanez, Director, PROMB.

The agreement reached by the "Dialogue Committee" required final ratification by Governor Romero-Barcelo and Senate President Hernandez-Agosto.

The Legislature had withheld $2.15 million from DNR's budget, and the Secretary was given the chance to meet with the "Dialogue Committee" to justify the programs and the expenditures. The major program involved hiring 294 persons for conservation and maintenance of 60 public beaches and 38 recreation areas. Most of the recreation areas were in the forests or natural reserves. The Secretary explained the urgent need to properly mantain forest recreation areas, and used the occasion to thoroughly explain her ambitious, and as yet only partially funded, forestry program. The Committee listened, becoming enthused by the economic, social, and ecological impacts of the forestry initiative. They approved reinstating the $2.15 million to the agency's budget.

Two days later, Virgilio Ramos informed the Secretary that the Committee had four million dollars unalloted, that they had been very impressed by DNR's projects, and that they were inviting the Secretary to present (within four hours!) specific proposals to spend the money. A task force including the Secretary, the PRFS Chief, and DNR staff prepared two proposals: one to expand DNR's beach cleaning effort throughout the island and a $2,789,500 proposal to finance the forestry initiative by creating the Puerto Rico

Conservation Corps. Its 391 members, with appropiate equipment, would be responsible for:

1. management/conservation of each of the 14 insular forests
2. management/conservation of DNR's natural reserves (Mona, Caja de Muertos, Jobanes)
3. reforestation projects on reservoir watersheds (Toa Vaca), retired agricultural lands (Finca Longo), and the surface area of an extensive limestone cave system (Cuevas de Camuy)
4. seedling propagation at two DNR tree nurseries (Cambalache and Monterrey)
5. expansion of the forest products utilization demonstration project that included: plantation thinnings, portable sawmill demonstration, wood and fence posts production, etc.

Both projects were positively recommended. The PR Conservation Corps was unanimously and enthusiastically received by the Committee. Senate President Hernandez-Agosto (a forester by training) and the Governor gave the projects their final approval within 2 1/2 hours. Through serendipity, and hard work, DNR's Secretary and her staff obtained the major funding for their forestry initiative.

With this kind of diverse and strong political commitment behind the new forestry program, the DNR had a unique opportunity to transform forestry resources conservation, management, and development in Puerto Rico.

B. Program change: the implementation of the forestry program

Implementing Change

When Secretary Diaz-Soltero came to the DNR in 1981, she decided that a strong forestry program would be a priority. During that spring and summer she consulted with experienced and knowledgeable foresters and ecologists like Frank Wadsworth and Roy Woodbury. She decided to name Ralph Schmidt as the Chief of the PRFS. Secretary Diaz-Soltero took a risk with Schmidt; it was practically unheard-of for a person not born in Puerto Rico to be named to an Assistant Secretary's position, but she wanted a very competent professional with formal forestry training.

The Secretary informed the PRFS Chief that she wanted a comprehensive forest management and conservation program and that she would lend her full support to the effort. They decided that planning should be an integral part of the program, but that certain needs were so urgent that they should be initiated immediately. They rightfully foresaw that recruiting, hiring and training key people, and identifying and purchasing specialized equipment, would take so long that action should be initiated at once. Concurrently an interactive planning process was initiated.

It is revealing to analyze how former DNR Secretaries organized the agency to neutralize a strong forestry program. Upon its inception in 1973 the Department was organized by functions. Different areas performed administration, research, planning, resources protection, and field operations. In other words, in this very unusual organization, planning for all resource programs was performed under one Assistant Secretary; protection for all resources was performed under another, etc.

DNR's extremely complex mandate included the management and conservation of all natural resources. The field operations area was administered through regional offices in seven coastal towns spred across Puerto Rico (Figure 1). The director of each of these regional offices was politically appointed. Although employees in the forests were designated within the budget of the Forest Service area, the Regional Director, who was not supervised by the PRFS Chief, distributed paychecks, approved and coordinated the repair and maintenance of vehicles, and the purchase of supplies and equipment. Within the psychology of the government worker in Puerto Rico, this made the Regional Director the _de facto_ supervisor of the forests and their employees.

The function of protection was performed by a uniformed, armed corps, the "Cuerpo de Vigilantes" or Ranger Corps (Figure 1). These employees were stationed in the regions, and patrolled and protected the forests under the supervision of the Ranger Lieutenant in charge of the region. Thus a kind of lip service was paid to the PRFS and its function of forest management, while in actuality other DNR areas were in control. These vested interests proved quite intractable, and the Secretary needed courage and constant determination to consolidate activities and truly establish forest management and conservation through the Forest Service. Luckily, established law and policy supported this effort.

New forestry activities

DNR's forestry initiative consisted of three major programs:

1) management of the insular forest system for multiple uses: timber, watershed and habitat protection, wildlife, recreation, and environmental education;
2) forest products utilization demonstration project: and
3) reforestation on private and public lands.

The Management of Insular Forests

Consistent with the PR Forest Law, the Secretary announced to the Regional Directors and to the Commandant of the "Cuerpo de Vigilantes" that the PRFS would have responsibility and authority over all decisions related to the management of the forests. To this the Secretary added a very important concept that would become the conerstone of the resource management field program: each forest (or natural reserve) would have a newly recruited, professionally trained, resident manager. In politics and public service, what is said and what is done are often two different things. In Puerto Rico's government agencies almost all employees are recruited through political contacts. Department veterans simply presumed that the Secretary was about to pack the agency with "her people". In fact, she maintained a completely hands-off policy on recruitment, leaving this to the PRFS Chief and his staff. Candidates were recruited on the basis of training, personal attributes, and willingness to work.

The Secretary's announcement to the Regional Directors that they would no longer run the forests received an early and severe test. During the first week of this new policy, the PRFS Chief noticed a bulldozer being transported through the Maricao forest. Another government agency had opened up a swath 30 meters wide and 1500 meters long in an area of old growth forest. It was learned that neither the Secretary nor the PRFS Chief had knowledge of the necessary permit. Upon visiting the site, where the damage was substantial and irreparable, and learning that the Regional Director had authorized the action without consulting or informing the Secretary, she dismissed him. As local political leaders, Regional Directors often have direct access to the Governor's office, and the decision was contested at that level, but eventually confirmed. More than any other single action, this established the

Secretary's commitment to a strong, technically oriented forestry program.

Through the Regional Directors and a skeleton crew in the PRFS central office, a low-key but functional recreation program was in place. Protection of forest habitat for water quality and wildlife needed improvement and strengthening, but was also on-going through the "Cuerpo de Vigilantes" and the Secretary's legal office. However, silvicultural and forest product utilization programs were practically non-existent.

The forest products utilization demonstration project

Starting in the 1930's with the CCC and continuing up through the 1960's, thousands of acres of valuable hardwoods and softwoods had been planted in the Commonwealth forests. No elaborate inventories were necessary to assess that almost all of these plantations were stagnated due to overcrowding and lack of thinning. Thus, the raw material was not only available, but sound silvicultural practice called for its removal.

The Secretary wished to emphasize strongly new reforestation planting in the forestry program, but the Commonwealth Forests had been completely planted or naturally regenerated for many years. Much of the prime land for reforestation was in private hands. It was felt that private landowners would be much more receptive to establish long term tree crops on their lands if the viability of extracting, processing, and marketing posts and lumber could be demonstrated. Thus it was decided to mount a forest products utilization demonstration project. Again, the Forest Law was supportive of this effort, establishing a revolving fund where all forest revenues could be deposited and reinvested in the forestry program without any appropriation or legislative scrutiny.

As of 1981, a small sawmill was located in the Rio Abajo Forest. It been purchased nineteen years before and had been broken for the last six months. Tanks and a pump that had been purchased for the construction of a hot and cold preservative treatment plant for posts and pilings had been stored in a warehouse for five years. There were only one or two functional chain saws, and no logging or skidding equipment. No posts or lumber were being produced in the forests.

The new forest products utilization demonstration project would:

1) demonstrate that commercial forest production was viable in Puerto Rico, stimulating reforestation on private lands and supplying much needed data on the economics of the operation;
2) increase productivity and health of over-crowded stagnated plantations, greatly enhancing their ultimate value; and

3) produce much needed revenue for the forestry program, including funds for land acquisition.

The two basic needs for such a program were equipment and trained personnel. Cambalache Forest was chosen as the demonstration center because of easy access and the existence of an available site for a forest products center. A technician was named to operate the post treatment plant in January 1982. A shed was built, tanks were installed, and chemicals purchased. Thinnings were commenced in the forests in the spring of 1982 and by July treated posts were available for sale. At this time a trained Puerto Rican forester graduated from Duke on a Commonwealth scholarship started working with DNR. Subsequently several field days were organized so that private landowners could observe logging techniques and production.

Following the advise of USFS experts who were visiting Puerto Rico, a portable sawmill was purchased in May 1982. The cost was $12,500 and two staff members were trained in its use in the United States for $1,500. It paid for itself in its first operation, a teak thinning in Cambalache Forest that took six weeks (12 days operation) and produced 6,000 board feet (value $18,000). In the fall of 1982 a small bulldozer with a skidding winch was delivered and put to continuous use constructing skid trails and logging. By the fall of 1983 an automatic post peeler was installed at the treatment plant. In late 1983 and early 1984 two farm tractors with skidding winches were added, as were flat bed trucks with hydraulic loaders. Professional staff working in the forests were trained in the safe use of this equipment.

The forest utilization demonstration project was expanded to cover the seven forests that were appropriate for this activity.

Reforestation

Perhaps the single most important objective of the PRFS was reforestation, simply measured by the number of acres of trees planted. In 1981, as in previous years, about 80 acres of trees were planted. The acreage planted more than doubled every year thereafter until 1985.

Trees Planted by P.R.F.S.

Year	Acres
1981	80
1982	178
1983	433
1984	898
1985	1,200 (estimated)

The strategy for accomplishing this reveals two basic considerations. First, three different methods or target areas were developed and pursued, each contributing to the reforestation accomplishment. Second, the simple sounding task of planting more trees meant the simultaneous development of several support-systems.

Secretary Diaz-Soltero's three lines of attack for planting trees have been described. Cooperative agreements for reforestation were signed with the Aqueducts and Sewers Authority, the Energy Authority, the Land Administration, and the U.S. Navy. In 1983, when the massive injection of funds for the Puerto Rico Conservation Corps was received, workers, foremen, and equipment were assigned to these projects. Cooperating agencies contributed land and often substantial amounts toward the operational budget of the projects. These projects were especially important because public agencies often owned land in larger blocks than were available in the private sector. These larger plantings were judged very significant for the eventual establishment of a forest industry. Insular forest lands that were apt for reforestation were planted by forest crews. In one case a Caribbean pine stand was naturally regenerated through a seed tree cut and a prescribed burn, a novel technique in Puerto Rico that could have a great impact on the economics of future reforestation efforts.

The greatest proportion of the reforestation effort (60-75% of annual planting) took place on the privately-owned lands. Several supporting systems had to be developed simultaneously to accomplish this planting.

Obviously nursery capacity had to be raised. The PRFS owned and operated a small nursery in Cambalache Forest. Federal and local funds were used to expand the nursery threefold and to mechanize to some extent. The PR Department of Agriculture operated a large nursery site where part of the operation was dedicated to cooperative production of tree seedlings. Upon urging from Secretary Diaz-Soltero, the Department of Agriculture completely rebuilt the shade facility, improving the quality and quantity of tree seedlings. In 1983-84 another nursery from the Department of Sports and Recreation was used to supplement production. The PRFS still needs an adequate nursery facility to be developed and funded completely, under its own jurisdiction.

Veteran nurserymen were skeptical when asked to double and triple tree production. In the past, demand had not been so great. In 1976 over one million Caribbean pine seedlings had been produced in the nursery and had had to be buried because of lack of demand from private landowners.

The desire of private landowners to plant trees was increased in several ways. In meetings with Agricultural Stabilization and Conservation Service (ASCS) and the USFS, per acre incentive payments under the Forestry Incentives Program (FIP) and the Agricultural Conservation Program (ACP) were increased, and through commitments obtained by the Secretary in Washington, the total amount was increased. Extension foresters were retrained in a special two week intensive session, and several new extension foresters (mostly graduates of agricultural schools) were hired. The program called for free delivery of seedlings to farms; thus, large diesel trucks were purchased, drivers recruited and trained. The Secretary and PRFS Chief devoted considerable time to a media campaign and public speaking engagements to stimulate interest in the private sector to plant trees for economic and ecological reasons. The demonstration forest utilization program has been described in detail. This effort was crucial to increase interest in the private sector as to well as justify funding. These diverse efforts were all essential to success: if any one had failed, the trees would not have been planted.

The growth of all university trained staff working in all kinds of field operations was as following:

Date	Total Professional Staff
December 1981	5
December 1982	11
December 1983	25
December 1984	40

Table 2 gives the details of the total PRFS personnel during these years. As this cadre of professionals grew, a new strategy for planning and implementing programs began to take shape.

Interactive planning process

The planning process within DNR was infamous for producing elaborate plans that were shelved and not implemented. Although a small but excellent group of professional resource planners were employed by DNR, there was little or no communication between planners and those in charge of field operations.

The Secretary was determined that the forestry program planning be comprehensive and that the plan be integrated with the actual work program. In conversation with USFS leaders, the State and Private Forestry Planning Assistance Program was mentioned as a possible aid to initiate a meaningful and useful planning process. When USFS planner, Robert McDonald, traveled to Puerto Rico to explain a possible procedure, his ideas were enthusiastically received by the Secretary and the PRFS Chief. The model called for Interactive Planning that is based on three operating principles:*

1. the participative principle,
2. the continuity principle, and
3. the holistic principle.

The participative principle asserts that personnel understand and appreciate the objectives, goals, and ideals of the organization best through participation in the planning process. The members of the organization do the planning, not an external agent.

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* This section is largely quoted from the Puerto Rico Forestry Resources Plan-Draft 1985. For a full description of Consensus Methodologies see "Creating the State Forestry Future" by Alexander N. Christakis, Center for Interactive Management, University of Virginia, Charlottesville, VA and Robert B. McDonald, Department of Agriculture, Forest Service, Atlanta, GA.

The continuity principle says that no plan, however carefully worked on, will be successful the first time it is used. Planning is an ongoing process, and plans must always be reviewed and updated. Because of this continuous review, the end product is more successful, people learn and grow, and the organization works better.

The holistic principle is subdivided into the principle of coordination and the principle of integration. The principle of coordination states that it is best for the units within an organization to coordinate their activities with one another. The principle of integration states that planning is most successful when the entire organization is considered. Together these principles suggest that all parts of the organization must be respected for an operation to run smoothly.

Seven metholodogies, called "Consensus Methodologies", were used in working with the Interactive Planning Model. These seven methodologies can be used together or separately, depending on the needs of the situation. The seven methodologies are:

Idea Writing

Nominal Group Technique

Delphi

Interpretive Structural Modeling

Options Field

Options Profile

Trade-off Evaluation Procedure

It was not simple to find a planner with the interpersonal skills and grasp of technical issues necessary to facilitate the interactive planning process, but DNR planner Celso Rossy enthusiastically attacked the job and learned through practice, counselling from McDonald, and formal training sessions in Virginia and Florida.

A series of all day workshops brought together professional staff from within the PRFS, DNR, and other Commonwealth and Federal agencies with personnel knowledgeable on forestry issues. Out of these workshops four priority goals were developed:

1. Reduce dependency on wood imports
2. Maintain and improve environmental quality
3. Provide quality recreational opportunities
4. Increase employment and income opportunities.

About thirty program goals were also developed and ordered into an intent structure (see Figure 2). Using a computer program and the judgements of workshop participants, program goals were arranged according to priority and according to which goals would contribute to the accomplishment of others.

The Plan, a concise hard hitting document of about fifty pages, was in draft form by the latter part of 1984.

Its impact through a time of political change and its importance right up to the present will be discussed later. At the beginning of the process of planning, field practioners and busy forestry division directors had been reluctant to forego daily duties and to sit down and talk about what should, could or would be done. But the highly structured nature of the meetings conducted by the facilitator-planner assured that time was not wasted, and concrete written products were continually produced. What McDonald had predicted from the start became true: operational personnel adopted the plan as their own, believing in it and having a stake in its accomplishments.

Funding

The Puerto Rico forestry initiative required various major sources of funding over a period of years. It was decided to obtain and increase funding by gradual steps, and to tap as many sources as possible: P.R. local funds, Federal funds, DNR's Special Forestry Fund and private contributions.

Demonstrating her commitment to forestry, in 1981 the Secretary redistributed DNR's budget. She allocated: a 33% increase for new PRFS personnel ($150,000) and $70,000 for equipment (bulldozer/skidder and portable sawmill) to produce forest products.

A second strategy was to revitalize DNR's Special Forestry Fund. The Fund, created by the PR Forest Law, receives all revenue from recreation, land use permits, and forest products sold by DNR. The PRFS was instructed to build a post-treatment plant and to initiate a major effort to thin plantations within the forest that had not been managed for 30 years. From a forestry management point of view, the plantations needed to be thinned. From an economic point of view, their wood products would be sold and that money would be deposited in DNR's Special Forestry Fund. New regulations for electronic equipment on forest peaks were completed and implementation started, with the potential of raising $100,000/yr. for the Fund. Also, the existing Recreation Areas Regulation went into effect, charging a user's fee of $0.50/person. Table 3 gives a detail of the total funds available to DNR from this Special Forestry Fund. The Secretary made a policy decision to use the monies from the Fund exclusively for the needs of the forestry initiative: personnel, equipment and materials. These funds proved to be vital and basic seedmoney for the program. Then, a major fundraising effort began outside the Department of Natural Resources.

Federal funds to help the forestry initiative were identified and targeted. They were the Agricultural Conservation Program (ACP) and the Forestry Incentives Program (FIP). DNR had been receiving these funds for years, but a large portion of them were returned to the Federal government, unused. The PRFS Chief met with Federal representatives on the island and explained DNR's new forestry initiative. A petition for additonal Federal funds was made. These two programs would be critical, since they gave economic incentives to private landowners to reforest their lands. ACP paid $209/acre and FIP paid $197/acre to a farmer for reforestation.

In November 1981, the Secretary paid a visit to the Chief of the USFS and his staff to explain Puerto Rico's forestry initiative. In a series of candid and thorough meetings, she conveyed DNR's commitment to forestry, informed them of all the efforts and initial accomplishments during 1981, and requested USFS's technical and economic help. Chief Peterson gave his total support, and in that meeting he gave DNR $237,000 for technical assistance, nursery expansion, a demonstration forest project, and forest planning. He also instructed the USFS to give additional incentives to Puerto Rican farmers in both the ACP and FIP Federal programs, which amounted to an additional $100,000 from November 1981 to September 1982.

Thus, with three strategies (DNR's budget redistribution; strengthening the Special Forestry Fund and targeting it only to forestry activities; and obtaining the personal commitment and economic support from the

USFS Chief), the Puerto Rico Forestry Program was on its way.

The next fund raising effort for the Secretary was to obtain local funds. A meeting was held with the Governor, in which he gave the program his support. Puerto Rico was going through a very difficult fiscal situation. Agencies had had to take cuts of $92 million in September 1981 (of which $800,000 were from DNR) to maintain a balanced budget. At the budget request hearing for DNR's 82-83 budget (held on November 1981), the agency requested $1,381,536 of local funds for its forestry initiative. OMB recommended only $636,352, and on March 1982 the Legislature approved that sum. Table 1 summarizes funds spent on DNR's forestry initiative.

Another major fundraising effort was directed at the PR Legislature during the "Dialogue Committee's" deliberations in the summer of 1983. The U.S. Congress had begun discussion on the creation of an American Conservation Corps, and DNR prepared a draft document of the Puerto Rico Conservation Corps. We have previously discussed the process by which the Secretary obtained the political commitment and funding (an additional $2,789,500.00) for the forestry program from the "Dialogue Committee" and the Puerto Rican Legislature. This was the major fundraising success, and from then on there was a sizable economic commitment of local funds to forestry. Table 1 gives detailed budgets for the forestry program from July 1979 to 1985.

For forestry, indirect fundraising from private contributions was another fundraising strategy. A group of private pharmaceutical industries in Barceloneta, P.R. had a major solid waste disposal problem. DNR suggested that they land treat secondary sewage sludge by applying it on areas to be reforested. By adding water and substantial nutrients and organic matter, productivity in the subtropical moist site would be substantially increased. Ground water and soil conditions would be carefully monitored by hydrologists. DNR would produce and donate the tree seedlings for the project. A consortium was formed by the industries, municipal and Commonwealth governments to implement the project. Thus, a major forestry project totally financed by private industry began. This may be a pilot project for other future sludge disposal in Puerto Rico.

Another special reforestation project was initiated on the island of Vieques after an agreement was reached between the Commonwealth of PR and the US Navy. An initial area of 200 acres is being planted, with the potential of increasing to approximately 8,000 acres.

It is almost impossible to guarantee the funding for a government sponsored program. But DNR used various strategies to lend continuity to its forestry budget and obtain further budget increases, such as:

- Keep the Governor and PROMB's technical personnel informed of program activities and successes.
- keep key legislators, particularly the President of the Senate Committee on Agriculture and Natural Resources, informed of the program.
- take key policy-makers, legislators and the media to one day outings to the forest where the forestry program would be thoroughly explained and demonstrations observed.
- maintain a continuous public education program on the economic, social, and ecological benefits of reforestation.
- give numerous speeches, TV/radio interview and newspaper columns (by DNR's Secretary and PRFS Chief).
- give a complete, up to date report on accomplishments and projects to OMB and the legislature every year, on the occassion of DNR's budget request hearing.
- conduct a yearly technical evaluation by USFS team of experts to address PRFS institutional development, accomplishments and suggested follow-up actions.

- finally, hard team work and success. As the saying goes: "success breeds success".

Cooperation with related Federal and local agencies and the private sector

One of the most difficult aspects of reestablishing a cycle of natural resource management is recruiting and/or training competent personnel. This is particularly true in Puerto Rico for forest management since no forestry schools exist. However, the technical staff that was recruited into the PRFS between 1981-84 (about 40 individuals as outlined earlier) is generally regarded by outside observers as an excellent team of professionals. A variety of strategies were employed to accomplish this. 85

Prior to 1981 several scholarships for natural resource management study abroad had been created and funded by the PR Central Personnel Office. Four graduates of master's degree programs, two in wildife management and two in forestry, joined the staff assuming key positions. These excellent education programs should be continued and expanded.

The closest and most significant cooperator with the PRFS was the State and Private Forestry branch of the USFS. The PRFS Chief met with grants program directors in Atlanta to explore available opportunities in programs such as Rural Forestry Assistance, Planning Assistance, Cooperative Forestry Management, Agricultural Conservation Program, Urban Forestry, and Nursery and Tree Improvement. In the early days of the new forestry iniciative Federal funding was very important.

Even more important was the cooperative training and technical advise that experienced State and Private personnel supplied to the PRFS. The PRFS Chief and his Forest Management Chief planned their wood utilization program while observing similar programs in Florida on a field trip organized by the USFS. When equipment had been acquired, a USFS team including logging, sawmilling and erosion control specialists was sent to Puerto Rico for two weeks. During that time a major timber thinning and processing was accomplished, and a pattern was set for future operations.

Prior to 1981 seed for forest tree planting was acquired in a casual and haphazard manner. A USFS State and Private Forestry expert visited the island several times, initiating a program that now includes: careful screening of seed suppliers to acquire the best possible seed for Puerto Rico (sometimes brought from as far away as Australia); systematic selection and collection of local seed trees; establishment of superior seed tree stands and seed tree orchards through grafting; and establishing a seed processing and testing facility.

Table 4 lists all the training undertaken cooperatively between the PRFS and the USFS during 1983 and 1984.

In addition to these training experiences several field trips and courses were organized for staff through the National Park Service, the US Fish and Wildlife Service, and the National Oceanic and Atmospheric Administration. A course on resource interpretation was conducted by Dr. Thomas Warder of the University of Wyoming.

The cooperative effort between the USFS and the PRFS was so successful that it was presented to the USFS Chief and suggested as a model for International Forestry Programs. The USFS has created a position in Puerto Rico (1985) that will report to the State and Private Forestry Deputy in Atlanta and work on Agency for International Development cooperative forestry programs throughout Latin American and the Caribbean. Many people contributed to this concept, but it is partially an outgrowth of cooperative achievements between the PRFS and the State and Private Forestry Branch of the USFS.

The USFS Institute of Tropical Forestry and the Caribbean National Forest operate in Puerto Rico. They have always maintained a very cooperative attitude, generously lending advise and participating actively in local training and seminar programs. Following a PR forest resource inventory conducted by the USFS in 1980, the PRFS cooperated with them on an inventory in Toro Negro Forest to assess that resource and improve field techniques. Later, in 1985 the PRFS and the USFS conducted the five year forest inventory update cooperatively. Project costs were greatly reduced and three Puerto Rican foresters were thoroughly trained in inventory and mensuration techniques.

The Yale School of Forestry and Environmental Studies (YSFES) had been sending professors and students to Puerto Rico to observe tropical ecosystems since 1975. The DNR Secretary and the PRFS Chief encouraged these visits, wishing to promote Puerto Rico as an ecological laboratory and site of tropical resource management technology transfer and information exchange. One student obtained a grant from the Tinker Foundation to inventory tropical tree plantations. After completing her project she invited DNR's Secretary to deliver the Woman's Seminar at Yale. During the visit many students expressed a strong interest in tropical forest ecology and management, and the Secretary strongly promoted a cooperative program between YSFES and the DNR, seeing this as a pool of talent that could be very useful in attacking unresolved resource management issues in Puerto Rico.

When the new dean, Dr. John Gordon, was named the following July, he visited Puerto Rico and the project took off. An on-going $250,000 grant was obtained by Yale from a foundation and The Tropical Resources Institute (TRI) was created. Field trips and classes are conducted in Puerto Rico and students perform work projects. These projects are dually sponsored and evaluated by a Yale professor and a Puerto Rico resource management agency professional. Such diverse topics as turtle nesting on Mona Island or the economic structure of the timber market in Puerto Rico have produced information that has had a significant impact on management decisions. The authors feel that Puerto Rico should expand these contacts, possibly with other institutions, and build or renovate a training and conference center. This would take advantage of Puerto Rico's unique tropical ecological diversity, modern infrastructure and central location bridging the U.S. and the greater Caribbean.

The role of various government agencies in the reforestation effort has been described as an integral part of that program. Two new reforestation efforts are starting in 1985 as a result of groundwork laid earlier. The U.S. Navy has funded a $200,000 pilot reforestation project in Vieques. This project is already showing that private entrepreneurs, who were awarded the contract, can be very efficient field operators. The consortium of pharmaceutical companies that utilize the Barceloneta wastewater treatment plant on the north coast are funding a reforestation project in order to land treat the sludge produced by the plant. The PRFS consulted on the design of this project and suggested Dr. Wade Nutter, a top water-quality expert in the field of land treatment of waste water, as a consultant to monitor the project. At present there are no adequate means of sludge disposal in Puerto Rico, and this project could become very significant as a means of producing biomass energy by utilizing nutrient-rich sludge.

C. The institutionalization of forestry programs

Programs require adequate finantial support and professional human resources to function properly, but just as important as money and personnel is proper organizational structure and institutionalized program planning. No matter how extraordinary and successful a program is, it cannot have an ad-hoc long term existance. Institutions must change and transform themselves to become permanent hosts to succesful, innovative programs. Otherwise, there is the risk of the program being distorted or disappearing.

The DNR, promoter of the new forestry initiative, would have to evolve to make The Forest Service an official, permanent part of the institution. As previously mentioned, DNR was originally organized in terms of its major functions. At that time (1973 to 1980) forestry was one of the activities under Operations (then called the Terrestial Resources Area), with the exception of forestry planning which was under DNR's Planning Area. Figure 1 is an organizational diagram of DNR in 1979-80. Although forestry did appear on the agency's organizational chart, only five professional level employees were working in the Forests Division. Forestry responsibilities were disseminated through Regional Directors, as described earlier. Very few workers were assigned to routine maintanence of forest recreational areas. There were no forestry management or development activities in the forests. Their budget was limited (Table 1).

In 1982 a first step was taken to institutionalize forestry programs. A new Forest Service Area was created, the sixth operational area of DNR (Figures 3 and 4). It was composed of two Divisions: Management of Insular Forests, and Technical Assistance and Reforestation. The Division for the Management of Insular Forests had the responsibility of administrating the 14 insular public forests, providing facilities for passive public recreation in the forests and mantaining a forest products demonstration program. The Technical Assistance and Reforestation Division was responsible for providing technical assistance to private landowners on the management of reforested lands. It also distributed tree seedlings for reforestation purposes. Table 1 lists the budgets and Table 5 lists personnel levels of the Forest Service Area. Most of the personnel had been hired in temporary positions, to give DNR the flexibility of trying out different organizational alternatives before finally choosing a permanent one.

At the end of 1983 the final organization was chosen: the Forests, Sanctuaries and Natural Reserves Area.

A New Organizational Framework for Action: The Forests, Sanctuaries and Natural Reserves Area

From 1981 on, forestry and the acquisition and protection of ecologically valuable lands was promoted agressively. By early 1983, it was evident that a new organizational structure to conserve, manage and/or develop all of DNR's lands was necessary. Under the DNR Secretary's leadership and personal supervision, a task force was created to carry out the institutional change. The new concept for the Forests, Sanctuaries and Natural Reserves Areas was created.

By 1983, the ecologically valuable lands of Puerto Rico under DNR's jurisdiction covered an area of approximately 81,000 acres, equivalent to 4% of the island's surface area. These lands could be subdivided into the following categories: forests, estuarine sanctuaries, wildlife refuges and natural reserves. Each one of these categories implies that:

- qualitatively, there are differences amongst the natural resources on each site;
- there are differences in the goals and objectives for the management of the natural resources of the site;
- there are different strategies for the preservation, conservation and/or development of the site's natural resources;
- there are different compatible human activities for each site and different tolerance levels for disturbances; and that

- there should be land managers with different academic backgrounds and professional/ technical expertise to manage each land category. (Example: forests managed by foresters; wildlife refuges by wildlife managers, etc.).

The land management activities of DNR were thus unified under the Forests, Sanctuaries and Natural Reserves Area. The four different types of land management units were administered by two bureaus, each having two divisions (Figure 5).

The Forest Service Bureau would institutionalize DNR's succesful forestry initiative. Its objectives would be to:

- instrument the public policy, directives and purposes of the Forest Law;
- obtain the multiple positive ecological benefits of reforestation;
- obtain positive socio-economic results produced by the establishment of a forest products industry; and
- manage the insular forest system.

The Forest Service Bureau was subdivided into two divisions, the Insular Forest Management Division and the Technical Assistance and Reforestation Division, one with two and the other with three sections.

The Sanctuaries and Natural Reserves Bureau was to be responsible for preservation, conservation, and/or management of or estuarine sanctuaries, wildlife refuges and natural reserves. Over 7,500 acres of ecologically valuable lands came into DNR's jurisdiction from 1981 to 1984, and there were plans for several future substantial land acquisitions. The eventual establishment and management of marine sanctuaries was taken into consideration in this sheme. This structure provided the basis for smoothly incorporating new areas into the appropiate management programs. The Bureau was subdivided into two divisions, the Marine and Estuarine Sanctuaries Division, and the Natural Reserves and Wildlife Refuges Division (Figure 5).

The new organization was formally approved in 1984, an accomplishment that required extensive justification and approval at many bureaucratic levels. The Office of Management and Budget approved it from the organizational structure and the fiscal point of view. The Central Office of Personnel Administration approved all the details on personnel, including job descriptions. Table 5 gives a detailed list of permanent (career) personnel positions created for the new Area. Table 2 gives the total number of persons actually named and working in the forestry effort during various years.

Chapter 4

A FOREST MANAGEMENT CONSTITUENCY

To achieve a succesful forestry program various important ingredients must be present. One of the critical ones is the development of constituencies that support continued forestry management activities. There are 3 constituencies:

1. the members of the DNR
2. the political constituency, and
3. the citizens of Puerto Rico

The creation of a constituency within DNR for the forestry program was initially the sole responsibility of DNR's Secretary. It was initiated during the 1981 task force analysis of the agency's priorities. During this process, other staff members of DNR realized the importance of a forestry initiative. To them, the profound multiple benefits that forestry would have on all natural resources was the most important argument. They were also interested in the higher visibility that a forestry program would give to DNR. Once the Secretary had selected the new PRFS Chief, and an initial cadre of forestry specialists had been recruited , they shared with her the responsibility of rallying support of other DNR members for the forestry program. The agency's interest was maintained during the development of the forestry program by:

- receiving short reports on staff meetings from the PRFS Chief that included a discussion of forestry projects, problems and accomplishments.
- sponsoring one day field trips to experience, first hand, forestry activities (for example: nurseries, plantations, recreation areas, wood treatment plant, etc.).
- hosting short training courses on forestry using DNR's expertise, USFS expertise or outside consultants.
- celebrating an annual meeting between the Secretary, all DNR Assistant Secretaries and PRFS Chief to set yearly program goals, objectives and budgets.
- giving an annual presentation of the forestry program to PROMB. This was done by the Secretary, with all senior DNR officials attending and participating.
- annually defending DNR's budget in four legislative committees:
  1. Senate Committee on Agriculture and Natural Resources
  2. Senate Budget Committee
  3. House of Representatives Committee on Natural Resources and Environmental Quality

4. House of Representatives Budget Committee

The Secretary presented the budget and senior DNR officials participated in all budget hearings.

- promoting the participation of forestry professionals in DNR's annual Symposium on Natural Resources.
- participating in informal and formal meetings to discuss forestry activities and interaction between the PRFS and other DNR areas.
- DNR professionals outside the PRFS participating in the PRFS four year interactive participatory planning effort that culminated on the Puerto Rico Forest Resources Plan (1985).
- invitating DNR personnel to monthly staff meetings of the principal USFS personnel (40 persons), where individuals reported on their forestry activities projects, problems and successes.
- promoting and celebrating informal social gatherings that included PRFS and other DNR personnel.

All of these activities should be encouraged and continued in the future to mantain the support of other DNR members for the PRFS and the forestry program.

The second constituency for the forestry program was a vital one: the political constituency. We have discussed in detail the process by which the DNR Secretary obtained political commitment. The political commitment of members of the PR executive and legislative branches was obtained by translating the forestry initiative into attractive political assets. This meant highlighting the information related to positive economic, and social impacts of the program, particularly the creation of jobs and the substitution of forest products imports. The members of the political constituency who best understood both the economic and ecological benefits were the USFS and the President of the Senate Committee on Agriculture and Natural Resources, Hon. Justo Mendez. To gather the political constituency support, the DNR Secretary relied primarily on short (1-2 hrs), well planned, thorough meetings where she explained the forestry program, its trascendental importance, benefits, and political advantages. Once their political commitment was obtained, and during the development of the forestry program, the Secretary met at least twice a year to give progress reports to and personally thank the politicians for their continued support. They were made aware that they were part of this enormous team effort; without their political and fiscal support it would have been impossible to initiate Puerto Rico's forestry revolution. Politicians appreciate thanks, and to be kept well informed on the developments of a program in which they have invested politically and economically. It is essential that DNR continues gathering and strenghtening political support for its forestry initiative, particularly with the change in Administration that ocurred in January 1985. The forestry program has momentum, but the new DNR Secretary, Hon. Alejandro Santiago, must make an effort to familiarize himself with the program and must committ himself to become its leader and supporter. He must continue to strengthen the political constituency's support. Otherwise, he won't be able to count on the major long-term and increasing sources of funds necessary for a viable forest management program.

The third constituency created to back DNR's forestry initiative was Puerto Rico's citizenry. This includes the general public, environmental organizations, other non-government organizations and private industry. The information used to attract their support was complete and balanced, explaining all the ecological, economical and social benefits of DNR's forestry initiative. The information was primarily given by the DNR Secretary and the PRFS Chief. To communicate the message they used radio, TV, and newspaper interviews; public keynote addresses on special activities; special newspaper articles featuring a particular activity of the forestry program; and a two minute television spot. The Secretary also used the PR forestry program as a major theme on special opportunities to address national and international audiences (Rome, Peru, Santo Domingo, USA) and university groups (UPR, Yale, PR Junior College). The interest of the public was mantained by giving public information on a continuous basis, at least bimonthly, repeatedly explaining the forestry program and giving an up to date summary of accomplishments. These efforts must be continued in the future to strengthen and further galvanize Puerto Rico's positive public opinion on sustained forestry management.

Chapter 5

PROGRAM CONTINUITY THROUGH POLITICAL CHANGE

With the change of the Secretary of the DNR in January of 1985, the PRFS and its personnel lost the privilege of being one of the Secretary's top priorities. Much excitment and apprehension accompanied the arrival of the new leader in the Department: who would survive? what would be the new program priorities? Puerto Rican politics are probably not much different from any other vigorous democratic system. There are jealousies, manipulation and intrigue, real and imagined.

Secretary Santiago-Nieves had one Undersecretary, three Corporation Directors, seven Assistant Secretaries, and several aide positions to fill. He changed everyone except two Assistant Secretaries and two aides. The Assistant Secretary for Forestry (PRFS Chief) and the Assistant Secretary for Research (a Department veteran actually associated with the new Secretary's party) remained. No one from the Forest Service was immediately fired. There were probably several factors involved in these decisions.

The original bipartisan support for the PRFS budget expansion undoubtedly resulted in several very important members of his own party communicating their support for forestry to the Secretary. The Secretary was a businessman, and the PRFS was producing about $200,000 annually through the sale of forest products, recreation permits and land use fees. Tampering with the program might endanger this income, which was to some extent a discretionary fund for the Secretary. The PRFS was receiving substantial Federal funds from several sources that might have been endangered if competent personnel were removed. The previous DNR Secretary had permitted the PRFS to hire based on technical qualifications with no political considerations; all the political parties were represented in the Forest Service. All of these factors tended to stabilize the program and personnel of the PRFS.

Nevertheless, the PRFS Chief had less access to the top executive and the decision making process than other newly appointed aides. When the new administration found it necessary to cut back all the agencies budgets by 6% for fiscal year 1985-1986, the PRFS budget was cut 23%! This meant no funds for supplies or equipment and freezing all vacant positions.

At this point (April 1985) a small beautiful island to the south of Puerto Rico, Caja de Muertos, came to play a key role in resource management in Puerto Rico and the future of the Forests, Reserves, and Sanctuaries Area. The DNR owned the island, where it maintained a resident manager (a marine biologist) and several guards and workers. Two students from YSFES had spent several months on the island and had produced a plan to manage it as a marine park. This plan stressed conservation, controlled use, monitoring, and environmental education. DNR professionals charged with the management of the island were personally committed to these goals. The island contained a magnificent Spanish lighthouse, almost one hundred years old, superb but limited marine resources, subtropical dry forests, and was an important breeding ground for endangered sea turtles and tropicbirds.

The new Governor of Puerto Rico, Hon. Rafael Hernandez-Colon wanted to create a program of economic development for political impact in the southern city of Ponce, an economically depressed area. Through the DNR Secretary word came down that Caja de Muertos should be reffited as a public beach, complete with snack bars, showers and toilets. A Port Authority ferry would transport hundreds of people on the forty-five minute trip to the island. The ecological impact of such a scheme to the dry, fragile ecosystems of the island was judged to be severe. But without even considering this, there were several compelling logistic reasons to question the concept.

The beaches were beautiful, but short and narrow, and backed by rocky promontories. Each fall the island was regularly hit by high waves and wind on its protected north side, and the dock necessary for mass transport would be vulnerable and very expensive to construct. There was no surface or subterranean fresh water on the island and disposed waste water in the beach area would inmediately seep into the ocean. There was serious question as to whether the public would favor a rough, one and one half hour boat ride to enjoy a beautiful, but challenging and austere, marine environment. Finally, if generation of employment was the goal, only a few ticket takers' and fast food vendors' jobs would be created, and the support system necessary for these people on an isolated dry island was known to be very expensive.

When these reservations were explained to the DNR Secretary he removed the resident manager from the island, and eliminated the jurisdiction of the Forests, Reserves and Sanctuaries Area over Caja de Muertos. The bond of trust was broken, and the DNR Secretary began to regard the Area (the PRFS being a part of this) as an obstacle to implementing his policies.*

Almost simultaneously a task force to reorganize DNR was formed. This group interviewed a great number of DNR employees and reported in writing to the Secretary that the

---

*The dock and ferry to Caja de Muertos was inaugurated by the Governor on television Labor Day weekend 1985. The torrential rains of October6-7, 1985 brought much tragedy to Puerto Rico, including the destruction of the new facilities at Caja de Muertos.

Forests, Sanctuaries and Natural Reserves Area was functioning as well or better than other areas of the agency. The report was discarded or shelved.

The Secretary was having continuing problems with the political leadership of his PDP party. In his Senate confirmation four top leaders of the party abstained, and the entire opposition rejected, giving him a majority of one vote for confirmation. Then, in July, the Senate Committee for Agriculture and Natural Resources announced an exhaustive investigation of how the DNR was being administered. The continuation of forestry programs was specifically mentioned in this investigation, and the PRFS Chief was inteviewed for several hours.

Upon the resignation of the PRFS Chief in November 1985, and the appointment of a close associate of the Secretary to replace him, the forest planner presented the PR Forest Plan (product of the interactive planning process described earlier), and it was enthusiastically endorsed by the Secretary.

Although incidents such as Caja de Muertos are probably unavoidable given the political dominion over executive agencies in Puerto Rico, the professionalism of the PRFS staff had assured the continuity of forest and natural resource management programs. Powerful political leaders who have never been directly involved in the agency are watchful for program continuity. Objective appraisal of the performance of professional staff will make it very difficult to remove well qualified staff. And a program that generates revenue and attracts Federal grants will be difficult to dismantle in times of shrinking government budgets.

The process of interactive planning assures that staff executing the program will have a stake in the policies established. It will be difficult indeed for the leader of an agency to deny himself the credit of these accomplishments. Furthermore, Department of Agriculture's strategic planning efforts directed at agribusiness in Puerto Rico have identified forest management as the appropriate economic use for more than 70% of the island.

The forestry program has now grown to the point that it no longer fits comfortably into the DNR. The potential for revenue is several times greater than what is being generated at present. The process of buying equipment, supplies, spare parts, and fuel is so slow that productivity and morale is severely affected. Pay scales are so low that the best workers will only stay a few years before better opportunities materialize. Reforestation efforts should be expanded if Puerto Rico is to reduce wood imports significantly. Merely to substitute softwoods and tropical hardwoods imported to Puerto Rico, 5,000 acres of each should be planted annually. Land analysis indicates that at least this much area (about 10% of the island once rotation age is reached) is available.

The creation of a new public corporation for forestry would help to solve many of these problems. It has been proved that the potential for substantial revenue exists; and that a first-class professional staff can be developed in Puerto Rico. Putting such professionals in secure, well-remunerated positions is the best guarantee of an integrated and efficient resource management program.

Chapter 6

THE CONDITIONS FOR SUCCESFUL ORGANIZATIONAL CHANGE

A successful organizational change, particularly in matters of natural resources, is a complex process and an important contribution. Let us discuss some of the major underlying factors that supported successful organizational change in forestry in Puerto Rico.

Characteristics of the innovator

The leader must be a visionary. He must be able to dream, and to think big.

The leader must have a unique grasp of his country's natural resources, their major problems, and the technological and policy alternatives to solve them. It is ideal if the innovator has had some formal training/education in natural resources. but a very sensitive and intelligent person could also do the job, without formal training.

The innovator must have a profound awareness of the historical context of his country. He must be able to understand the chosen economic, social and political strategies of his country and its principal political parties. Then, he must have the ability to understand and to carve out a role for the country's natural resources within the total scenario. It is important to relate those natural resources to sustainable economic development, to health, to an improved quality of life, to a better environment, and to beauty.

The innovator must be a strong leader. He must be dynamic, inspire confidence and trust, and convey a sense of optimism that things can change positively.

The innovator must be a good communicator, but also a good listener. He must be able to convey his dream and his ideas, as well as the project's problems and needs to different audiences using different media. It is essential that he be open and perceptive so as to be able to listen to, assess, and incorporate valuable ideas for his project from others.

The innovator must be a good salesperson. He must have the ability to explain his project from many, and sometimes diverse points of view. He should be aware that what may attract a politician to a project is a different aspect than that which attracts a scientist, a natural resource manager, a budget administrator or a Governor. He should be able to have a comprehensive, holistic understanding of the project, and then choose those project qualities that will be more enticing to various constituencies.

The leader must have courage and he must dare to set forth new, bold ideas.

The leader must have political savvy. He must be sensitive to political needs; be aware of the actors in the political scenario, their interests and dislikes, their relationship to each other; project confidence dealing with politicians; and, most importantly, understand a politician's mind and mode of operation.

Political Reception and Support

It is impossible to promote and succeed in a major natural resource initiative on a small island without a positive political reception and support. The conservation, management, and development of natural resources on these islands is usually the government's responsibility. Non-governmental, non-profit civic organizations concerned with the environment are few, with scarce human and economic resources and limited technical expertise. Governments are run by politicians, and in Puerto Rico politics pervades every aspect of life. The PR forestry initiative has been succesful because work and care were invested into the process of informing, lobbying for economic and philosophic support, and sharing successes at many levels and with diverse groups of the political power structure (See Chapter 3, political commitment).

Public Reception and Support

Governments should inform their people of government projects and initiatives. After all, they are being carried out for the benefit of the people. But the PR forestry initiative went beyond merely informing the public. There was a concious effort to explain the reasons for embarking on the forestry initiative, as well as the important ecologic, economic, and social benefits of the program. Multiple means were used to contact the citizenry: radio, TV interviews and spots, newspaper articles and interviews, keynote addresses, demonstration projects, environmental education, creation of volunteer groups, etc. As the citizens learned about the project and approved it, a unique positive response was echoed on the political scenario. The approval of both the people and the politicians had a unique synergistic effect, giving more momentum to the forestry initiative.

Legislative and legal backing

Puerto Rico was very fortunate to have a comprehensive and complete set of environmental laws enacted by 1980. DNR has an extraordinary group of environmental laws and regulations to conserve and develop Puerto Rico's natural resources. To have the jurisdiction of all natural resources under one Department is wise. It facilitates resource management and conflict resolution. It minimizes activities with major negative impacts on any one resource and bureaucratic delays.

It is essential to have most, if not all, environmental laws in place to facilitate a major natural resource initiative. Otherwise, it may be necessary to dilute energies between two causes: promoting approval of environmental laws while at the same time working on new environmental programs. Usually, scarce human resources on small islands cannot cope with both efforts simultaneously. To first achieve the enactment of the environmental law has an additional benefit: it serves as an educational process to legislators and politicians, who will later be more sensitive to environmental issues and programs when approached for their political, philosophic, and economic support.

Legislative support for a new natural resources effort is vital. It is the Legislature that appropriates the funds and approves the executive programs for natural resources conservation and development. Without funds the innovator's dreams will never become reality. In the PR forestry initiative, the DNR Secretary took care to obtain and sustain strong legislative backing for the program. The success of this effort was evident when the major funding appropriation for forestry was obtained from the Legislature, even during the politically charged confrontation of the "Dialogue Committee".

The role of scientific information

The scientific information needed to embark on the PR forestry initiative was available and accessible. For many decades ITF had been established and carried out numerous research projects on many forestry and forestry-related problems. They had published results. Also, ITF contains one of the best tropical forestry libraries in the world. ITF scientists, particularly Dr. Frank Wadsworth, were eager to help the local government in their forestry initiative, and they were generous advisors throughout the program's planning and implementation.

It is important to have valid scientific information to embark on a major natural resources program. Otherwise, disaster might occurr, not only for the program, but for the environment. On the other hand, it is impossible to have all the necessary information before a project begins. Thus, the leader, with the advice from his scientific staff, must assess how much scientific information is sufficient to proceed with the natural resource project. In the PR forestry initiative we filled "information gaps" by doing research while simultaneously developing the forestry program.

Ensuring program stability and continuity despite political change

This is the most difficult goal to achieve. To guarantee the existance, stability, success, growth, and continuity of a government natural resources program is almost impossible. In Puerto Rico, we used various strategies that might help achieve that elusive goal. Based on our experience and with the benefit of hindsight, we suggest the following actions to any renewable resource agency interested in an organizational change:

1. Gather political support in all political parties, at all levels, on a continuous basis.
2. Develop and maintain a strong constituency for the program within the executive agency, at all levels and in all other programs.
3. Recruit the best technical and non-technical personnel based on their educational background, experience, capacity, and motivation to work.
4. Choose a strong, dinamic, technically competent leader. Secure a permanent career position for him and his subordinates, to mitigate future political harassment.
5. Develop a public constituency among the citizens. Their understanding and support will motivate the agency to future, larger goals, and also will serve as a safeguard against total project destruction.
6. Develop special friends in the communications media. They will serve as watchdogs for the program, and quickly report problems and potential disasters.
7. Record program history, from the earliest policy decision to daily activities. It is harder to destroy a program that has written

proof of its successful existence. Disseminate the information as much as possible. Organize regular meetings or symposia to discuss project achievements, needs, and future plans.

8. Transmit program information to local, national, and international forums. Program recognition is recognition for your country. It is difficult for politicians to destroy a program that has placed the country on the national or international scenario.

9. Diversify sources of funding. This may guarantee its existence even in the event of a major policy change in one of the funding sources.

10. Establish an organization that promotes and allows for professional growth. Give personnel incentives such as salary increases, fringe benefits, but most important: educational, travel, and training experiences.

11. Start the natural resource initiative with enough lead time before the next possible political change. Develop and institutionalize activities and programs, securing budget, permanent organizational structure, and personnel career positions.

12. Avoid the direct association of a natural resources program with a charismatic,

visionary creator. Future political administrations will resent the association and the program will be negatively affected.

13. Develop and publish a long range plan for the conservation/development/management of the natural resources involved in the program. It should explicitly and clearly set program goals, objectives, stages of growth during a period of years, personnel and budget needs, and expected results. Use participatory planning techniques to gather total support for the planning effort and the final product. The plan will become, in effect, a roadmap for the future, even after political change.

Pre-requisites to organizational change in local government renewable resource agencies in U.S. insular areas.

Each one of the US insular possessions is a unique world, with different history, culture, traditions, and governmental and political organizations. We must be cautious in directly transfering Puerto Rico's successful forestry initiative into any of these situations.

But there are a few factors that seem to be absolute pre-requisites to achieve successful organizational change or development in local government renewable resource agencies in other U.S. insular areas:

1) the existance of a strong and visionary leader, the innovator
2) political support, including legislative support

Factors which are important, but not essential are:

1) public support,
2) scientific information, and
3) legal backing.

The fragility and limited resources of islands makes sound renewable resource management all the more crucial, while limiting the pool talent available for the job.

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GLOSSARY

ACP	Agricultural Conservation Program
ASCS	Agricultural Stabilization and Conservation Service
CCC	Civilian Conservation Corps
CNF	Caribbean National Forest
DNR	Department of Natural Resources
FIP	Forestry Incentives Program
ITF	Institute of Tropical Forestry
NPP	New Progressive Party
PDP	Popular Democratic Party
PR	Puerto Rico
PRFS	Puerto Rico Forest Service
PROMB	Puerto Rico Office of Management and Budget
TRI	Tropical Resources Institute
US	United States
USFS	United States Forest Service
YSFES	Yale School of Forestry and Environmental Studies

Table 1
PR FORESTRY PROGRAM BUDGET
(monies spent)
Commonwealth of Puerto Rico
Department of Natural Resources

Year Source Funds	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86*
Joint Resolution of the General Fund	$200,000.**	$486,823.	$540,692.	$610,840.	$2,268,605	$2,345,661.	$1,911,969.
Forestry Special Fund	$ 45,595.	$ 58.514.	$ 68,984.	$107,878.	$ 165,245.	$ 161,742.	$ 187,287
Federal Funds	$ 86,575.	$ 53,700.	$114,400.	$157,800.	$ 249,943.	$ 313,858.	$ 664,510.
Total	$332,170	$599,037.	$724,076.	$876,518.	$2,683,793.	$2,821,261.	$2,763,766.

Source: DNR Budget Office, 1985

* Appropriated funds
** Approximate

Table 2
PR Forestry Program Personnel

Year	Number of Persons
1979-80	55
1980-81	73
1981-82	62
1982-83	94
1983-84	254
1984-85	292
1985-86	290

Table 3
Forestry Special Fund
Department of Natural Resources

Year*	Fund Income
1979-1980	$ 45,595
1980-1981	$ 58,514
1981-1982	$ 89,822
1982-1983	$156,080
1983-1984	$194,530
1984-1985	$176,495

*Note: Puerto Rico's government fiscal year starts on July 1 and ends the following June 30.

Table 4
Cooperative Training in the PRFS

Weeks	Specialty	Instructor	Location	Participant
3	Utilization	W. Darwin	P.R.	PRFS personnel
4	Tropical Dendrology	R. Woodbury	P.R.	" " J. Figueroa
2	" "	W. Darwin R. Westbrook	U.S.	J. Perez R. Morales
1	Tree Improvement/ Seed quality	L. Leigel C. Lantz	P.R.	PRFS personnel
1	Chainsaw	CNF	P.R.	PRFS personnel
1	Equipment show		U.S.	J. Figueroa
1	Silviculture/ Inventory	D. Sims	P.R.	B. Cabarle
2	Reforestation/ Silviculture	W. Balmer	P.R.	PRFS personnel
1	Inventory/ computer	W. Darwin D. Sims	U.S.	B. Cabarle
1	Sawmill Improvement/ Harvesting/ Computer	W. Darwin	U.S.	J. Perez
2	Reforestation/ Hydrology	L. Bishop K. Bowman	U.S.	D. Jimenez, L. Vega, L. Gonzales
1	Hydrology	Douglas, Nutter	P.R.	15 participants
1	Nursery	S. Nursery Conference, S.C. Container Nursery & NTSL	U.S.	A. Vergara L. Zamot
5	Tree improvement, seed quality	Local experts	Thailand Australia Fiji	R. Schmidt

Table 5

Civil Service Personnel Positions Created in the Forests, Sanctuaries and Natural Reserves Area

Office of the Assistant Secretary of Forests, Sanctuaries and Natural Reserves

1 Assistant Secretary
1 Natural Resources Specialist V
1 Executive Director IV
1 Accountant III
1 Executive Secretary I
1 Secretary IV
1 Stenographer II
1 Auto Driver I

Forest Service Bureau

Office of the Director

1 Natural Resources Assistant Director
1 Natural Resources Specialist III
1 Executive Secretary I
1 Clerk II

Insular Forests Management Division

Office of the Division's Chief

1 Natural Resources Specialist IV
1 Secretary III

Management Section

1 Natural Resources Specialist II
14 Natural Resources Specialist I
4 Natural Resources Technician III
8 Natural Resources Technician I
1 Truck Driver
3 Foreman
23 Worker II
71 Worker I

Recreation Section

1 Natural Resources Specialist I
1 Natural Resources Technician IV
26 Worker I

Land Use and Permits Section

- 1 Natural Resources Specialist II
- 2 Natural Resources Technician III
- 1 Engineering Draftsman III
- 1 Secretary II
- 3 Worker I

Technical Assistance and Reforestation Division

Office of the Division's Chief

- 1 Natural Resources Specialist V
- 1 Natural Resources Specialist II
- 1 Secretary III

Technical Assistance Section

- 1 Natural Resources Specialist II
- 1 Natural Resources Specialist I
- 1 Natural Resources Technician IV
- 1 Natural Resources Technician III
- 8 Natural Resources Technician I
- 1 Secretary II

Production and Distribution Section

- 1 Natural Resources Specialist II
- 1 Natural Resources Technician III
- 1 Natural Resources Technician II
- 1 Natural Resources Technician I
- 1 Secretary I
- 3 Truck Driver
- 5 Worker

Sanctuaries and Natural Reserves Bureau

Office of the Director

- 1 Natural Resources Specialist VI
- 1 Secretary V

Marine and Estuarine Sanctuaries Division

- 1 Natural Resources Specialist IV
- 3 Natural Resources Specialist I
- 1 Secretary II
- 6 Worker

Natural Reserves and Wildlife Refuges Division

1 Natural Resources Specialist IV
8 Natural Resources Specialist I
1 Natural Resources Technician IV
1 Secretary II
2 Worker II
7 Worker I

Figure 1

Department of Natural Resources
Simplified Organization Chart, 1979-80

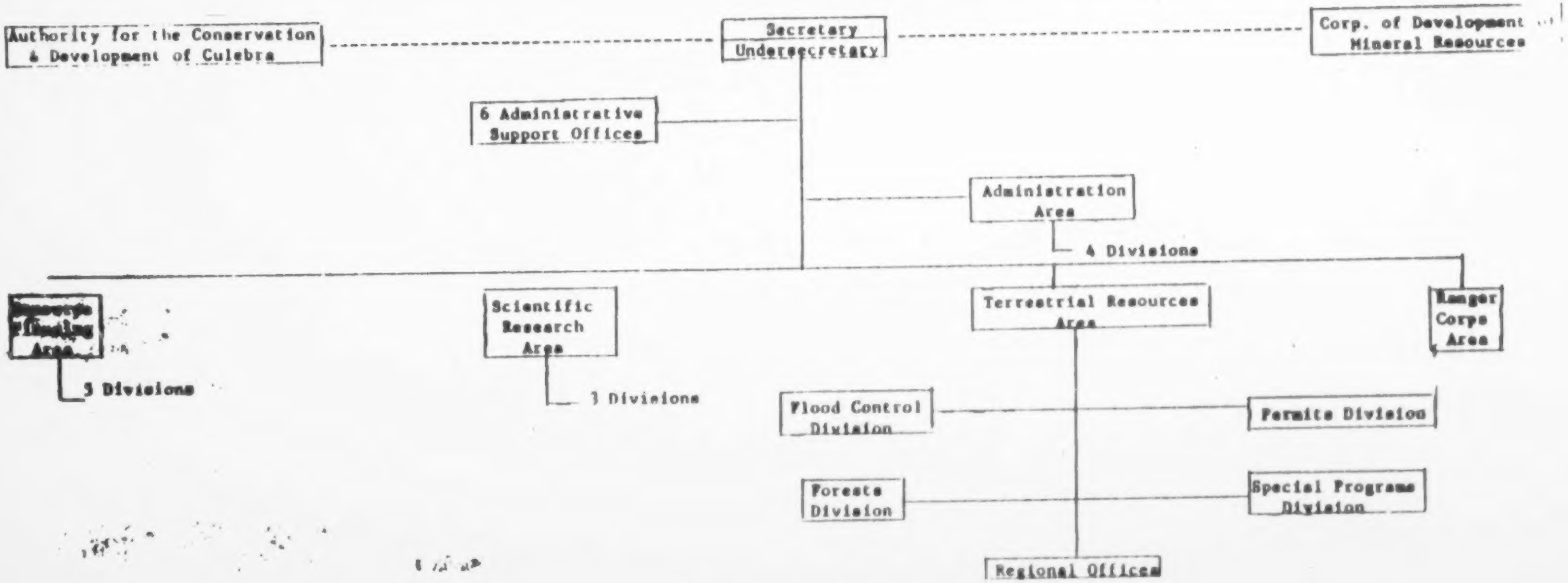
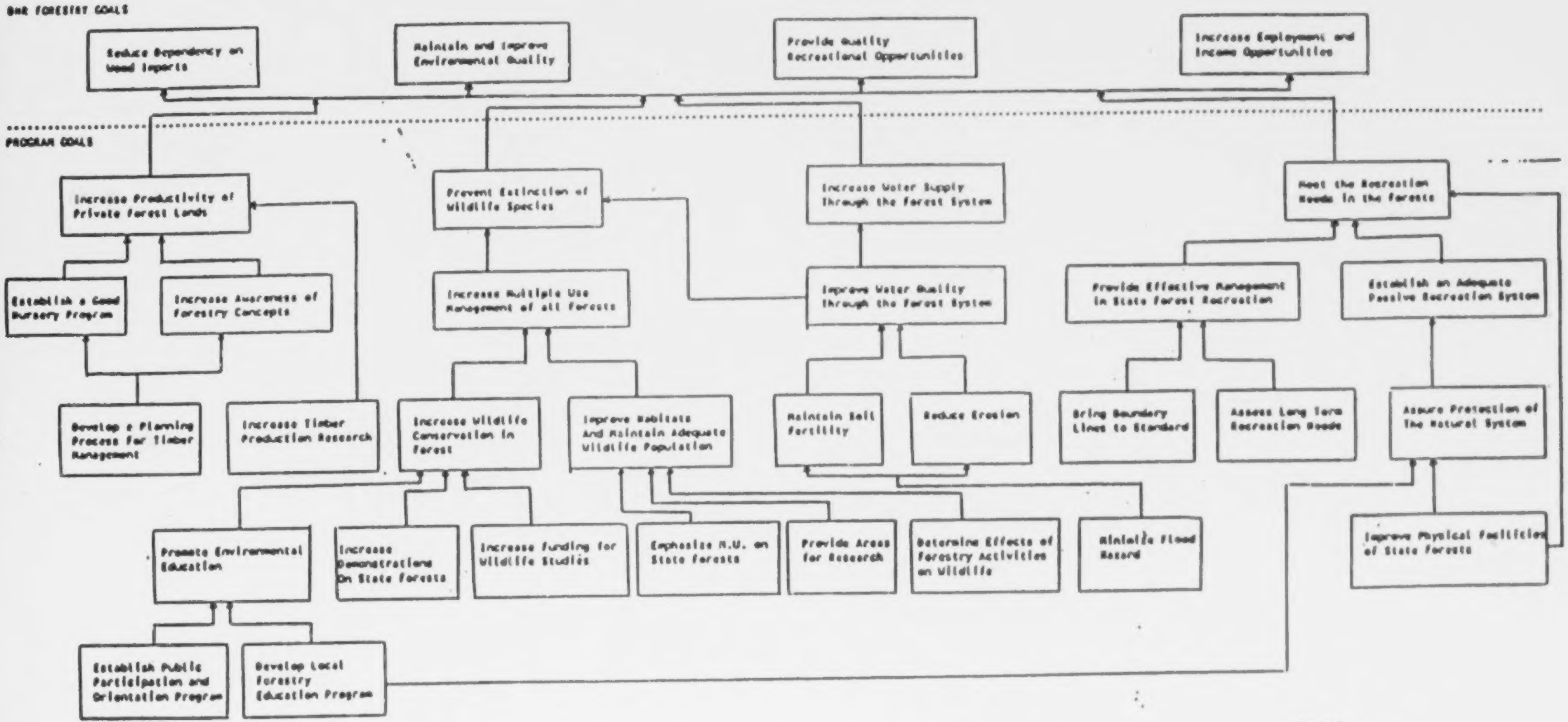

Authority for the Conservation & Development of Culebra
Secretary
Undersecretary
Corp. of Development Mineral Resources
6 Administrative Support Offices
Administration Area
4 Divisions
[illegible] Planning Area
3 Divisions
Scientific Research Area
3 Divisions
Terrestrial Resources Area
Ranger Corps Area
Flood Control Division
Permits Division
Forests Division
Special Programs Division
Regional Offices

FIGURE 3

ORGANIZATIONAL CHART

INTENT STRUCTURE: HOW THE COMMONWEALTH FOREST SERVICE GOALS RELATE TO ONE ANOTHER


DHR FORESTRY GOALS
Reduce Dependency on Wood Imports
Maintain and Improve Environmental Quality
Provide Quality Recreational Opportunities
Increase Employment and Income Opportunities
PROGRAM GOALS
Increase Productivity of Private Forest Lands
Prevent Extinction of Wildlife Species
Increase Water Supply Through the Forest System
Meet the Recreation Needs in the Forests
Establish a Good Nursery Program
Increase Awareness of Forestry Concepts
Increase Multiple Use Management of all Forests
Improve Water Quality Through the Forest System
Provide Effective Management in State Forest Recreation
Establish an Adequate Passive Recreation System
Develop a Planning Process for Timber Management
Increase Timber Production Research
Increase Wildlife Conservation in Forest
Improve Habitats And Maintain Adequate Wildlife Population
Maintain Soil Fertility
Reduce Erosion
Bring Boundary Lines to Standard
Assess Long Term Recreation Needs
Assure Protection of The Natural System
Promote Environmental Education
Increase Demonstrations On State Forests
Increase Funding for Wildlife Studies
Emphasize M.U. on State Forests
Provide Areas for Research
Determine Effects of Forestry Activities on Wildlife
Minimize Flood Hazard
Improve Physical Facilities of State Forests
Establish Public Participation and Orientation Program
Develop Local Forestry Education Program

Legend
Helps to Accomplish ________
DHR, FORESTRY SERVICE AREA 1983

Figure 3

DEPARTMENT OF NATURAL RESOURCES
SIMPLIFIED ORGANIZATION CHART, 1983

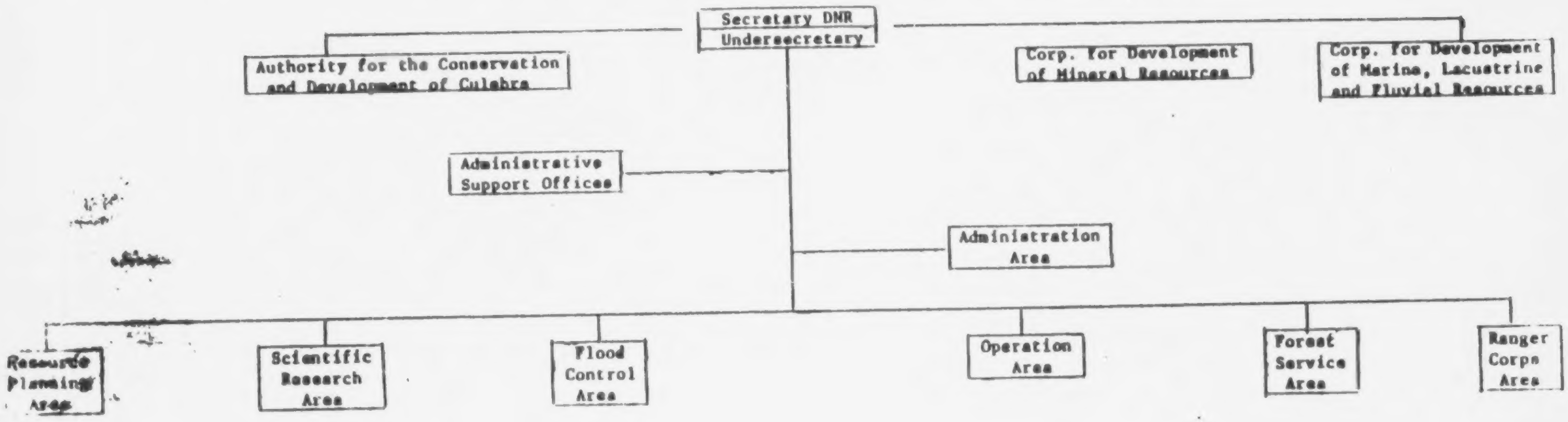

Secretary DNR
Undersecretary
Authority for the Conservation and Development of Culebra
Corp. for Development of Mineral Resources
Corp. for Development of Marine, Lacustrine and Fluvial Resources
Administrative Support Offices
Administration Area
Resource Planning Area
Scientific Research Area
Flood Control Area
Operation Area
Forest Service Area
Ranger Corps Area

Figure 4

DEPARTMENT OF NATURAL RESOURCES
FOREST SERVICE ORGANIZATION CHART, 1982

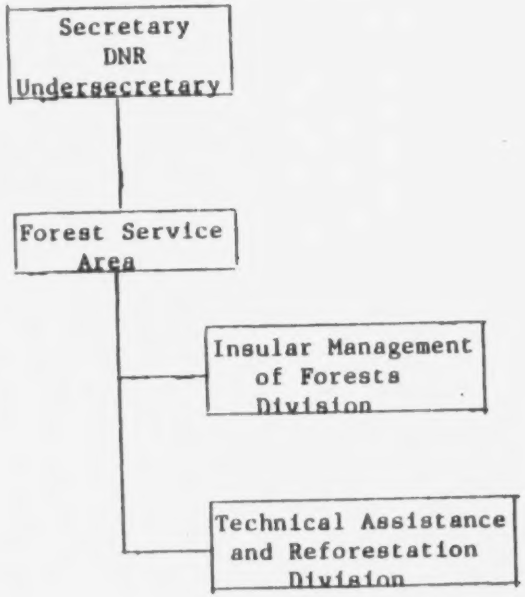
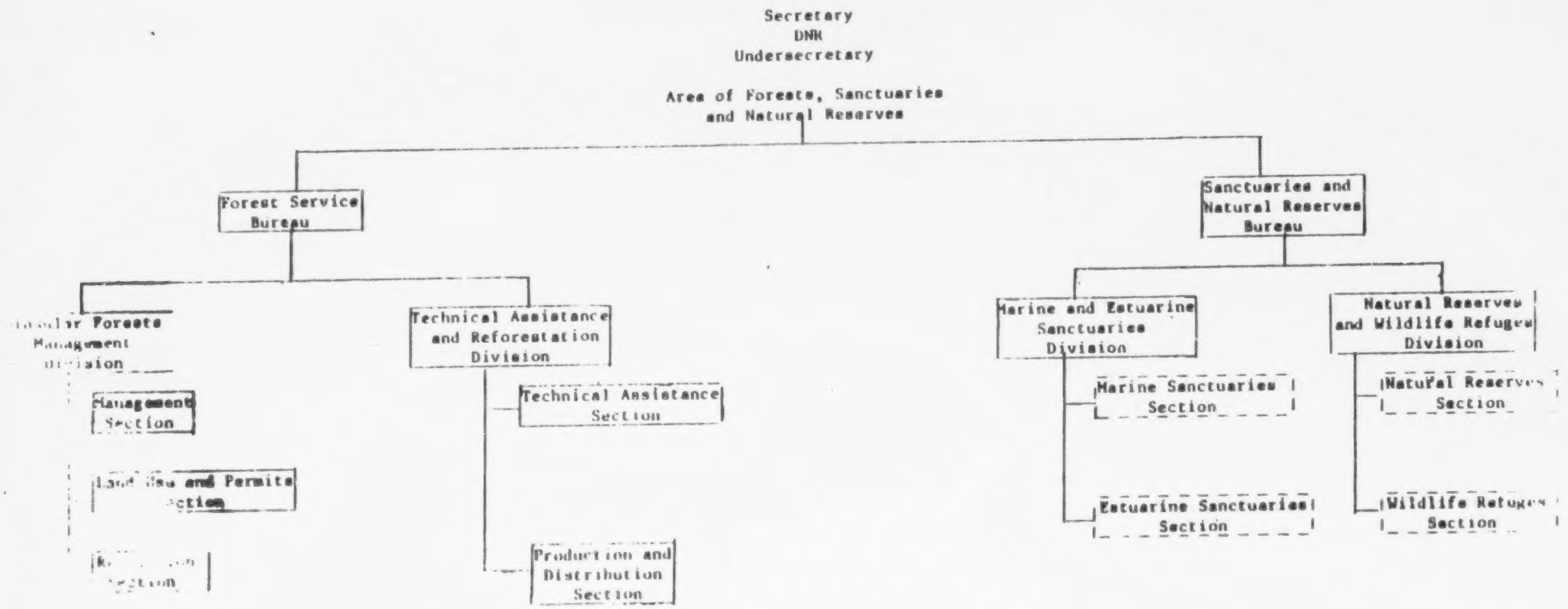

Secretary
DNR
Undersecretary
Forest Service Area
Insular Management of Forests Division
Technical Assistance and Reforestation Division

Figure 5

ORGANIZATION CHART OF THE FORESTS,
SANCTUARIES AND NATURAL RESERVES AREA, 1984


Secretary
DNR
Undersecretary
Area of Forests, Sanctuaries and Natural Reserves
Forest Service Bureau
Insular Forests Management Division
Management Section
Land Use and Permits Section
[illegible] Section
Technical Assistance and Reforestation Division
Technical Assistance Section
Production and Distribution Section
Sanctuaries and Natural Reserves Bureau
Marine and Estuarine Sanctuaries Division
Marine Sanctuaries Section
Estuarine Sanctuaries Section
Natural Reserves and Wildlife Refuges Division
Natural Reserves Section
Wildlife Refuges Section

Dotted rectangles refer to future expansions.

August 1984